ANNUAL REPORT - 1950

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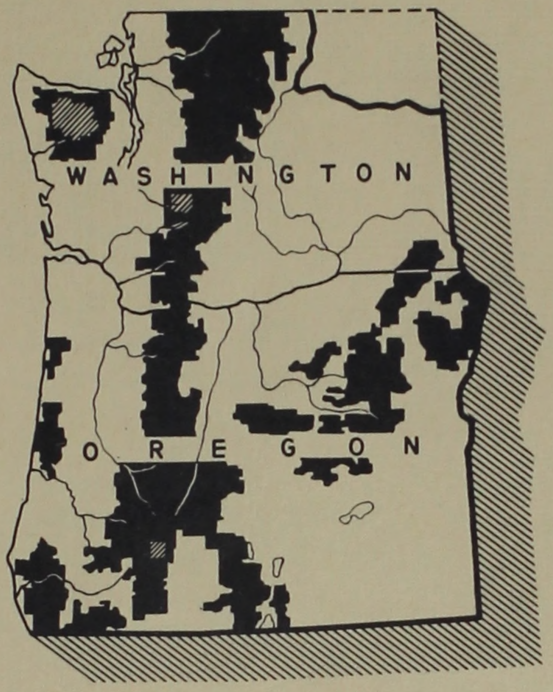

U.S. DEPARTMENT of AGRICULTURE • FOREST SERVICE
PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION
J. ALFRED HALL, DIRECTOR
PORTLAND, OREGON
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ANNUAL REPORT TO THE CHIEF OF THE FOREST SERVICE OF THE PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION FOR THE CALENDAR YEAR 1950

INTRODUCTION

It is becoming increasingly difficult to get forest and range research done between wars. After all, a period of five or six years for accelerated research effort in between periods of doing rush defense jobs with diminished manpower is not the ideal way in which to achieve optimum results.

Fortunately, some research installations are of such a nature that they can be laid away for a few years until the opportunity again arises to see what has happened in the intervening time. If the installations are well designed, good results will come from them. Better results could be obtained with closer application of needed effort, but, these days, we must do as we must.

In spite of these handicaps, a recapitulation of results obtained during the recently passed period between wars shows real progress. Activation of all experimental forests in the national forests and the creation of a very valuable new one in the Willamette have afforded excellent opportunities for major advances in fundamental silviculture, applied forest management, range management, and range rehabilitation. At least the groundwork has been laid for future work in forest and range influences in the watershed management field by laying out forest and range areas designed and adapted for that work.

Of particular importance is the establishment and operation of a small chain of cooperative second-growth experimental forests in the Puget Sound and Olympic Peninsula areas. These, with the Cascade Head Experimental Forest plus certain special study areas on other forests, are beginning to yield a steady flow of fine results in management of young stands that vary widely in age class and composition. Partial cutting of various types and degrees, clear cutting by very small areas where necessary, pruning for profitable growth on good stems, and many other intensive management measures are being studied, demonstrated and, in some cases, already proven practical.

It has been a remarkable fact that some measures developed in this work have been put into use by certain large operators even before the research men were well satisfied as to their thorough practicality. But, this is not true of the enormous bulk of small ownerships of young timber. In far too much area, premature and destructive cutting of thrifty, young growing stock continues to be the rule. This serves to emphasize again the need for intensified measures of education and demonstration aimed to reach small forest ownership.

The heavy and spectacular harvest of old timber in the Douglas-fir region obscures the fact that the major permanent resource of the region lies in the younger age groups. The Forest Survey estimates that:

The area of old growth = 8.15 million acres.
The area of young growth = 13.35 million acres.

Thus, the area of timber from seedling to 160 years old exceeds the old areas by 64 percent. This is the future of the wood industries in the Douglas-fir region and the realization of the growth capacity of this stock carries the insurance of future production.

The forest control laws and their administration in Oregon and Washington should be strengthened very soon by the incorporation of further measures aimed to preserve this thrifty growing stock. Its management by intensive methods is now possible in many cases because of improved markets for the qualities of wood that are removed by these measures. Pulpwood, poles, piling, fiberboard, small sawlogs: these are some of the product needs that can be supplied from young-growth thinnings and intermediate cuttings, removed so as to accelerate volume growth and improve quality in the stands.

In the pine region, the picture is a little different for considerable progress has been made in the application of methods of light selection cutting that are not widely applicable to old Douglas-fir. This practice tends to perpetuate the mixed-age stands typical of the east side. Thus, the area of young versus old growth is not as clearly shown by the figures available for pine as for fir.

In either case there are three principal ways of extending the timber supply:

(1) Improve utilization, reduce mortality, and increase net increment of old growth.
(2) Improve utilization of "associated species."
(3) Increase growth and yield from young growth.

To these must be added for the long pull reclamation by reforestation of all favorable sites now deforested or inadequately stocked.

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Impending shortages of wool and meat may call attention harshly to inadequate progress in restoration of depleted range lands. There is a backlog now of sufficient research results to give high probability of success in revegetation of broad areas of range. There are still broader areas on which no such guarantees can be given without more work.

In any case, it is established that range revegetation is not the simple task of distributing seed that has sometimes been described. It is a major agricultural operation that depends for success upon delicately balanced weather and soil conditions. Also, before very large programs are undertaken, commercial sources of seed for those species and strains found suitable by research must be developed.

Research has found numerous superior strains of grasses for this work and is developing methods for their establishment. Correlation of species, strain, site, and methods remains to be accomplished in the more difficult situations.

Important advances in knowledge of soils, west side and east side, have been made in the last few years. Progress in this field is now held up by the calling of Tarrant back to the Navy. There have been and will be other losses of key personnel to the military forces.

Gratifying progress has been made in the field of flood control survey and the ability of that activity to contribute to the Columbia Basin Comprehensive Agricultural Program. Flowing from this work is increased interest in watershed management.

Expanding markets, new industries, and continued interest in the field have brought marked improvement in utilization. At last, considerable progress is being made in the utilization of decadent Douglas-fir, a major obstacle to good management of old stands. Still lacking are the bulk outlets that are required for both old- and young-growth logging and milling waste. Increases in use by hardboard plants will help but far more consumption is needed.

Significant progress in utilization of alder offers promise of economical reclaiming of a great deal of land to more valuable conifers.

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All in all, with occasional setbacks, the period between wars in the Northwest has been a time of real progress in forestry.

FOREST ECONOMICS

Forest Survey

Completion during 1950 of the computation and analysis of results of the reinventory of the forests of the Southwest Oregon Unit--composed of Coos, Curry, Douglas, Jackson, and Josephine Counties--discloses the relative importance of this last large forest frontier of the Pacific Northwest. Here on 1.4 percent of the Nation's commercial forest land is contained 10 percent of its total volume of saw timber. The reinventory found a total of 153 billion board feet of saw timber, in terms of Scribner rule (163 billion in terms of International $\frac{1}{4}$-inch rule), in the unit. Although forest utilization has been large scale in Coos County for nearly three decades, its progress into the other four counties of the unit has come largely in the last 10 years; rapid expansion here dates from the earlier years of World War II. Growth of the sawmill industry has been spectacular--in 1940 there were 138 mills with a combined production of 825 million board feet of lumber; in 1948, 461 mills produced a total of 2,123 million board feet. Growth of the plywood and veneer industry has been even more striking; in 1940 there was one active plywood plant of small capacity; in 1950 there were 13 active plants and 3 under construction. Combined rated annual capacity of the 16 plants in 1950 was approximately 773 million square feet of 3/8-inch, 3-ply plywood. To date cutting operations have covered about one-sixth of the commercial forest land area in the unit and saw-timber stands still occupy close to three-fourths of the area.

Completed during the year was the survey of commodity drain in 1948 and release of the report "Commodity Drain on Commercial Forests in Oregon and Washington, 1948." Total commodity drain on the live saw-timber inventory of the two States amounted to 13,953 million board feet, Scribner rule; on the primary growing stock commodity drain was 2,724 million cubic feet.

Other reports released during the year were: "Production of Logs in Oregon and Washington, 1925-48," and "Forest Statistics for Lake County, Oregon." The first of these reports presented a summary of statistics collected annually on the volume of logs produced in the two States, by species and county; the second summarized results of a reinventory of the forests of Lake County, Oregon.

All field inventory work was in Washington last season. Reinventories of Cowlitz, Pacific, and Skamania Counties were completed, and some field work was done in Grays Harbor County.

Projection of types from aerial photos to base maps was completed for Clark, Pacific, Cowlitz, and Wahkiakum Counties. One-inch-to-the-mile detailed revised type maps were drafted and published for Coos County, Oregon, and for Cowlitz, Wahkiakum, and Clark Counties, Washington. Drafting was begun on the revised type map for Pacific County.

Office compilation of type areas and timber volumes was completed for Coos, Clark, Wahkiakum, and Cowlitz Counties, and the determination of growth and mortality was completed for Coos County.

Next season field work is planned to cover the remainder of Grays Harbor County and all of Lewis and Thurston Counties, unless the staff is needed on defense jobs of higher priority.

The staff prepared and published a revised Forest Survey Field and Office Manual for the Pacific Northwest Region during the past year. Though designed for in-Service use, copies have been in demand by technical personnel outside the Service.

Despite considerable progress in improving survey techniques, costs per unit of area surveyed have continued to increase. This has been due to higher salaries, increases in travel and equipment costs, and more intensive standards. Therefore, next year even more emphasis will be attempted than in the past to integrate and apply statistical and photogrammetric techniques to inventories. The objective here will be to stretch Survey dollars over greater acreages and still produce standards of work meeting the manual specifications.

Last season, for the first time, photo volume plots were substituted for part of the field plots which otherwise would have been required to meet inventory sampling intensities. For even-aged stands in northern Skamania County an average of nine photo plots was substituted for each field plot discarded, without increasing sampling error of total volume estimates. Since it costs approximately twenty times as much to take a field plot as it does to take a photo volume plot in that kind of country, a cost saving was obtained by these substitutions. Plot volumes were determined from aerial photos by estimating total stand height and stand density and reading gross stand volumes from tables based on those factors. Photo plots taken at locations where field plots were also taken provided a regression of field estimate of net volume over photo estimate of gross volume per acre, which was used to adjust the average estimate from all photo plots. This method is very promising for reducing field work and inventory costs in inaccessible areas wherever any reasonable correlations of photo to field volume estimates are obtained. However, in some cases where good correlations are possible, full advantage of possible reductions in numbers of field plots may not be taken merely to estimate total volumes within prescribed accuracies. The limiting factor controlling reduction of field plots may be the minimum number of field plots required to determine such essential details as volumes by species which may not be determined accurately enough by photo techniques.

The division cooperated again this year with the Oregon State Forest School in giving a one-week Aerial Photo Short Course for practicing foresters.

A study to evaluate both ground and aerial photo techniques for estimating tree mortality was made cooperatively by the division, the Portland Forest Insect Laboratory of the Bureau of Entomology and Plant Quarantine, the Bureau of Land Management, the Division of Forest Pathology of the Bureau of Plant Industry, and the Oregon State Board of Forestry. Thirty narrow rectangular plots averaging seven acres each were established in saw-timber types in southwestern Oregon and studied both in the field and through interpretation of large-scale aerial photography. When the analysis of these data is complete it should provide some answers on both field and aerial procedures useful in estimating mortality. The field data provided an excellent supplement to mortality estimates for the southwestern Oregon unit made by standard Forest Survey plots on the reinventory. Since the cooperative plots were permanently marked, they will no doubt be re-examined on future reinventories by Forest Survey and probably at more frequent intervals, by other cooperators or other agencies as well. Next season it is hoped that re-examination of at least part of the plots may be made, not only to establish mortality trends but to permit fuller investigation of the possibilities for estimating mortality by photo interpretation.

Mortality

Lumber Grade Recovery Studies

During the year additional work was done on the old-growth Douglas-fir lumber recovery study project which was started at this Station several years ago. In cooperation with the Regional Office, Bureau of Land Management, and the West Coast Lumbermen's Association, detailed studies were made in two Oregon mills. At the Kogap Lumber Company mill in Medford, lumber tally by grade was obtained for 650 logs. The other study was at the Cape Arago mill at Coos Bay where individual log data were obtained for 324 logs of various sizes and grades. Computation work on these two studies has almost been completed and will soon be summarized in Station reports.

Including these two projects, a total of five lumber grade recovery studies in the old-growth Douglas-fir type have been made. However, several more are needed to complete an adequate sampling of the various lumber-producing areas and types of old-growth Douglas-fir timber.

FOREST UTILIZATION SERVICE

The need for developing simultaneously management of forest lands and utilization of the material grown has increased throughout the past year. More and more operators in Oregon and Washington are thinking and planning not only on how they can perpetuate their raw material supply but also how they can better utilize the raw material available to them. The concept of integrated utilization is uppermost in the minds of progressive operators. Although this development has been in large part

brought about by the vigorous and active competition for stumpage and logs, it has had the effect of impressing upon operators the multiple use of wood. The great spread in price between peeler logs for plywood and sawmill logs for lumber has created a competition which no longer can be met by individuals who log a timber stand solely for the manufacture of one product. The question uppermost in the mind of the operator, whether he is operating on a second-growth timber stand or an old-growth timber stand, is how to remove the most material from the woods and maintain the best competitive position.

An example recently has been brought to our attention. A small sawmill operator who kiln dried only the clear lumber produced has experienced the impact of competition from operators who sort their logs for multiple products. As a result, this operator has reorganized the operation, integrating with the sawmill a plywood mill which not only uses high-grade peelers but also low-grade material. Furthermore, a contract has been made with a pulp company for the pulp logs. The utilization in this operation is excellent and maximum yield of products from the areas logged is now obtained. This one operation is typical of a large number throughout the region which are either in the planning stages or have started construction. Within the last few weeks six new plywood mills integrated with sawmills have been announced. One large pulp mill now is in operation in the Upper Willamette Valley, using low-grade logs from which the clear, sound material has been utilized in other parts of the integrated operation.

Another area has seen the development of plywood mills based upon second-growth Douglas-fir. Here, again, the products removed from a timber stand are sorted. The material suitable for peeling is sent to the veneer mill, that suitable for lumber production goes to the sawmill, and the remainder is used for pulp. No longer are we in an era where a timber stand can be logged economically solely for the manufacture of one product.

Some of the major projects of the Forest Utilization Service during the past year have been:

1. The utilization of "white pocket" Douglas-fir.

2. An investigation of the relation of the quality of logs to their manufacture into various products.

3. The seasoning of second-growth Douglas-fir.

4. Veneer and plywood from second-growth Douglas-fir.

5. The utilization of red alder for pulp, veneer, and miscellaneous products.

6. The integration of hardboard plants with other operations.

7. The development of the wood hydrolysis process for the production of a wood-sugar solution and its subsequent conversion to molasses, yeast, and alcohol.

8. A better basis for the production of laminated wood products.

9. The development of integrated utilization centers.

Reduction in "Waste" in Logging Operations

Of primary concern to National Forest Administration and to a large part of the timber industry is the management problem which has developed in the defective old-growth Douglas-fir stands, principally in southwestern Oregon. Much wood substance is not being used in this region because of the high percentage of unmerchantable material which must be left in the woods. The answer to the harvesting of this type of timber lies in the development of new markets and new products which can utilize Douglas-fir containing Fomes pini (white pocket). Considerable emphasis has already been placed on this problem. Recently a stand was visited where a current logging operation revealed a cull factor of 60 percent of the gross volume. The area was clear cut and it was difficult to distinguish the areas from which the merchantable logs had been yarded. Much of the material remaining would be of peeler grade were it not for the Fomes pini infection. The activation by the Forest Products Laboratory of a project to evaluate this material for the production of lumber, veneer, and plywood is of major importance.

It is not likely that any one product made from Fomes pini wood can stand the cost of harvesting the presently unmerchantable logs from the woods. Multiple utilization will be necessary. The products made to date both experimentally and commercially, if one excludes pulp, use only very selected parts of the log. It will be necessary to develop a large-scale use, and it is encouraging that industry is rather widely interested in the production and merchandising of products made from this material.

The strength properties of Fomes pini lumber have been partially evaluated by the Forest Products Laboratory at Madison, Wis., and the Oregon Forest Products Laboratory at Corvallis, Oreg. More laboratory investigation and study is needed, especially in considering the combined effects of Fomes pini and knots on the strength of a single piece in order to provide a substantial basis for classifying the lumber into commercial grades and standards covering lumber items.

Both the strength and gluability of Fomes pini veneer need to be thoroughly evaluated before this material can be considered as a potential source of plywood. While it admittedly has suffered an appreciable deterioration of strength, the remaining strength undoubtedly is adequate for many uses. The large volume of this material, much of which is

available in logged-off areas where roads already have been constructed and even falling costs are paid for, will force consideration of utilizing this material.

Log Grade Study

Considerable progress was made in studying the relation of log quality and the products which can be produced from logs of various types. As part of this long-range cooperative project of the Forest Products Laboratory, the Regional Office, and the Experiment Station, four studies were made at different plywood mills in Oregon and Washington. In all cases complete woods data were obtained for the approximately 90 logs used on each study. The defects in each separate log were diagramed and a photograph was taken of its cross section. In addition, a photograph was made of the veneer at each 1-inch on the radius of all blocks. Representative veneer was graded for this study both in the green state and after drying. No detailed analysis of these data has been made yet. As soon as the analysis progresses sufficiently, plans will be made for the next year's investigations.

In addition to evaluating logs for lumber and plywood, it is planned to evaluate them for the production of pulp chips.

Seasoning of Second-Growth Douglas-Fir

The Douglas-fir lumber industry is reaching a period in its history where second-growth logs are becoming an important factor in the log supply for lumber production. This new type of Douglas-fir harvested from unmanaged stands presents, however, some problems in seasoning. The Douglas-fir lumber industry has always marketed a large portion of its output, especially the common grades, in a green condition. Green old-growth Douglas-fir could be stockpiled without much economic risk from blue stain and decay due to the low moisture content and high resistance to decay found in the heartwood since old-growth Douglas-fir lumber is practically all heartwood. In second-growth Douglas-fir, however, the sapwood is relatively thick and constitutes a high proportion of the lumber output, practically all of which is classified as common grade. This sapwood material, unlike the heartwood, is high in initial moisture content and is readily subject to blue stain when stored in bulk under warm conditions. Consequently, it is more necessary to season lumber cut from second-growth Douglas-fir trees than from old-growth in order to maintain good marketability. The interest of industry in seasoning second-growth Douglas-fir lumber stock at the mill continues to increase.

The seasoning of lumber cut from second-growth Douglas-fir logs may present problems quite different from that of old growth. The high moisture content of the wood, undoubtedly, will lengthen the required drying time. In some species lumber cut from second-growth material

warps and twists more than that cut from old-growth trees. Laboratory studies have already indicated that Douglas-fir might be more fortunate in this respect than many other species. The results show, for example, that the density and shrinkage properties of second-growth Douglas-fir compare favorably with the comparable interior portion of old-growth Douglas-fir.

Compression wood does not seem to be seriously prevalent in second-growth Douglas-fir and we may expect this material to season without excessive warping and twisting. Industry has also found that second-growth Douglas-fir trees develop a relatively high percentage of upper grade common (No. 1 Common and Better). Such lumber is characterized by relatively small but sound knots which, therefore, may have the possibility of being dried to a lower moisture content level than the 18 to 20 percent level currently being used in industry for old growth without serious degrade in planing.

We have need, therefore, for further laboratory and industry study of the seasoning performance of lumber cut from second-growth Douglas-fir to develop the best seasoning practice for this increasing supply of lumber in this region. The seasoning problem is further complicated by the fact that much lumber produced from second-growth Douglas-fir trees is cut in small mills which have not been able to equip themselves with conventional types of dry kilns and the steam boiler plants necessary to heat them. Efforts to develop a relatively low-cost type of kiln adapted to drying lumber at moderate temperature levels and heated with relatively inexpensive units may help materially in bringing about more widespread seasoning practice for this lumber.

Veneer and Plywood

The production of plywood from second-growth Douglas-fir material is just beginning. Without waiting, however, for a complete exploration of the properties and performance of this kind of plywood, present market conditions are enabling some producers to convert young timber of peelable quality into plywood for uses such as sheathing, etc. The use requirements for sheathing are not as extensive or intensive as those for most of the plywood which has been produced from old-growth Douglas-fir. Sheathing glued with interior type of adhesives can find many uses where it will remain continuously dry and where the demands for strength are not high. Further, faces of high quality appearance are not required, so the problems of patching the veneer and finishing the panel, quite common when using old-growth Douglas-fir veneer, are not encountered here. This type of use may represent a large segment of the potential plywood market and the experience gained by the producers now initiating the manufacture of plywood from second-growth veneer will go far in steering such production into dependable and profitable channels. Laboratory research may well find ways of better producing veneer from young-growth trees and enlarge the field in which plywood produced from it will give satisfactory service.

Red Alder Utilization

Interest in the utilization of red alder has increased considerably, not only for lumber for the furniture market but also for the production of veneer and miscellaneous wood products. Among these latter the most important is the market for paper roll plugs. The increased paper mill capacity has reflected itself in the active demand for paper roll plugs. The most important development, however, has been the announcement by one of the large pulp and paper companies that 2 million feet of red alder would be required for conversion to kraft pulp.

The main problem in the pulping of red alder has been its bleaching. At least a partial solution of this problem has been reached. The Forest Products Laboratory has under way a complete evaluation of red alder for use by various pulping processes. This will aid appreciably in stimulating a market at pulp mills for what has long been considered a weed species except when grown in river bottoms where the species attains sawlog size.

The management of formerly Douglas-fir land where the fir has been replaced by red alder has long been a problem. It appears that appreciable headway now has been made on the utilization of this species.

Hardboard

The active market for wood products, the need for integrated utilization operations, and the prospect of strong demand for 5 to 10 years have stimulated construction of hardboard plants in Oregon and Washington. Four hardboard plants are now in operation, four more are under construction, and two additional ones are in various stages of planning. Of the four in operation, two use the wet-form process while the other two are using the dry-form method. One of the hardboard plants using the wet-form process is making plans to double its capacity. Of the four hardboard plants under construction, one will use the wet-form method and three will use the dry-form method. Of those under consideration, one of each general type is being planned. These plants to date all use Douglas-fir "mill waste" either from a veneer plant or a sawmill.

While the capital investment for these plants is high in relation to sawmills, it is less than half of what would be required per ton daily capacity for an unbleached kraft pulp mill. The same type of raw material is required for both plants with the possible exception that a hardboard plant can use even a lower quality.

Wood Hydrolysis

The rehabilitation of the Springfield plant has progressed to the point where it should come into full operation during the coming

year. Several hundred tons of wood molasses have been produced experimentally. This material has found a ready acceptance by producers of mixed stock feed. The demand is active. Because of the advance in the price of industrial alcohol to more than 90 cents per gallon and its active need for synthetic rubber, the plant is being rehabilitated now to produce industrial alcohol.

Most of the experimental work during the past year has been in the conversion of "sawmill waste" to a wood-sugar solution. This was the part of the plant which caused trouble when it was previously in experimental operation. Much progress has been made.

Cooperation

Active cooperation has been maintained with major research institutions in Oregon and Washington, both those supported by the two States and by industry. At the Oregon Forest Products Laboratory at Corvallis, Oreg., one major project, the comparison of the properties of second-growth and old-growth Port Orford cedar, has been recently completed. This project has involved not only the Experiment Station and the Oregon Forest Products Laboratory but also the Forest Products Laboratory at Madison.

Assistance was given the Oregon Forest Products Laboratory by both the Forest Utilization Service and the Forest Products Laboratory in conducting its annual dry kiln course.

The two agricultural experiment stations in Washington and Oregon have been actively engaged in feeding trials for yeast and wood molasses.

RANGE RESEARCH

The Division of Range Research during 1950 continued to concentrate on research in the rehabilitation and management of summer ranges of the region.

Grazing Management Studies

Nearly all of the effort in grazing management research was aimed at initiating a detailed study of systems of grazing and intensity of stocking with cattle, using twelve pastures on the Starkey Experimental Forest and Range in the Blue Mountains of Oregon. Pending completion of the necessary fences, water developments, roads, and other facilities that are necessary to carry on these grazing studies, much of the research effort has been devoted to developing a better understanding of the vegetation on the Starkey, its soils, what changes have taken place in the vegetation since 1939 when the Starkey was first surveyed, and refining the techniques which will be employed in the grazing study.

Detailed plans for collection of data on the vegetation in the experimental pastures are being drawn up. Using conclusions from studies of sampling techniques conducted during 1947, 1948, and 1949, a sub-sampling system was devised and tried out in one of the pastures during 1950. The procedure devised worked so well that it will be used in all pastures for collection of data on changes in vegetation, condition, and trend and pattern of utilization that result from the different grazing treatments employed.

The goal of having part of the experimental pastures serve as experimental watersheds has been attained. Dr. Wilm of the Division of Flood Control Surveys examined the areas included in the experimental pastures and found that drainages in six of the pastures were definitely adaptable as experimental watersheds. This means that range influence studies can definitely be tied into grazing management studies at this Experimental Forest and Range.

Vegetation changes since 1939 have been variable on the Starkey. An analysis was made of some of the range survey data collected in 1939, 1944, and 1947 to determine what changes in density and composition of vegetation had occurred during the 8-year period. From this analysis, it was found that vegetation on the major portion of the Starkey range had improved since 1939, but on some portions it had deteriorated.

The largest increases in grazing capacity occurred in the ponderosa pine-pinegrass-elk sedge subtype, where an average increase of 118 percent in grazing capacity had taken place during the 8-year period. In contrast, the average increase in grazing capacity for both the ponderosa pine-bunchgrass and open grassland subtypes was only 40 percent. In the ponderosa pine-pinegrass-elk sedge subtype 100 percent of the range showed improvement as compared to only 70 percent of the open grasslands. A decrease in grazing capacity occurred on 20 percent of the open grassland, and no change took place on 10 percent.

In general, the open grassland areas showing improvement were those which still have a relatively deep soil and which were favored by management practices. Open grasslands occurring on thin, rocky soils showed little or no improvement, and in some cases showed decreases in grazing capacity of as much as 30 percent.

The substantial increases in grazing capacity which occurred in the ponderosa pine-pinegrass-elk sedge subtype are believed to be largely due to recovery from effects of logging. These areas had been logged just prior to the time that the initial records were taken in 1939. From our studies of the effect of logging on range forage production, it is known that logging often materially reduces forage production and grazing capacity. In some cases, where the intensity of cut was high, as it was on the Starkey, grazing capacity may be reduced as much as 50 percent the first year after logging. Thus, it seems

reasonable that the data taken in 1939 on the ponderosa pine-pinegrass-elk sedge type were influenced in a major way by the logging that had just taken place, and that the increase in grazing capacity from 1939 to 1947 was primarily recovery from logging. To this might be added the effects of opening up some relatively dense conifer stands and a general reduction in shading and competition for moisture afforded by the trees.

Five general types of soil were found on the Starkey. An exploratory survey was conducted on one of the 600-acre pastures in 1949. Five general types of soil derived from recent basalt flows, from loessial deposits of pumicite, or from a mixture of the two, were found. The pumicite found in this survey is a finely subdivided volcanic ash or dust of about the size of very fine sand or coarse silt. It is very resistant to weathering, and the soil derived from it contains very little clay. Soils derived from pumicite deposits in cultivated areas have been found of rather low fertility in comparison with other arable soils, and it is probable that low fertility also characterized the pumicite soils found on the Starkey. The five soils found are as follows:

1. A shallow, red soil covered by grassland. This is a residual soil, derived from basalt and usually found on ridge tops. The plant cover has been badly depleted by overgrazing and considerable erosion has taken place. As a result the soil shows no significant profile development and it is low in organic matter and badly dispersed.

2. A shallow, gray soil covered by grassland found on south slopes and benches. This soil is residual derived primarily from basalt, but some pumicite is found in the profile. In physical characteristics it is similar to the shallow, red grassland soil, but usually has better drainage.

3. A brown, residual soil found on south slopes and terraces. Open stands of ponderosa pine with an understory of pinegrass or bunchgrass characterize this soil. Only small amounts of Douglas-fir are found growing on it. This soil is of rather heavy texture, derived primarily from basalt but with some pumicite mixed in. It generally has a good profile development and structure.

4. A gray, deep, transported soil derived from basalt and pumicite that occurs on gentle lower slopes and alluvial fans. It is generally covered by a mixed stand of ponderosa pine, grand fir, Douglas-fir, and occasionally larch. It has good profile development and good water-holding capacities.

5. A gray, deep soil occurring on north and east slopes covered with dense patches of grand fir, Douglas-fir, and lodgepole pine. It is locally known as "tamarack soil." The parent material of the surface and upper horizons is pumicite while the subsoil generally is a buried profile of soils developed from basalt. Drainage is satisfactory to

excessive in the upper horizons of the profile, but may be impeded by the underlying rock strata or heavy residual soil.

These five types of soil doubtless have some strong implications with regard to forest or range management. It is probable that there will be major differences in range condition and trend standards for the various soils, and it is already clear that there will be differences in species and methods used for reseeding areas disturbed by logging. Completion of this survey for all of the pastures on the Starkey is essential. Moreover, it is hoped that the information derived from this survey can be spot-checked in other areas of the Blue Mountains to permit a more widespread understanding of soil and site characteristics.

Range Reseeding Studies

Results from all range reseeding studies in the region were embodied in the range reseeding handbook for Region 6. The first draft has been completed. This handbook, being prepared jointly by research and administration, includes in addition to all of our results applicable results from other agencies and experience gained on full-scale seeding projects. Prepared for in-Service use, it presents the best information we now have at hand on all phases of the range reseeding job from planning through to grazing management of the reseeded stands.

Methods used in preparing the seedbed may reduce the gopher population. This was an interesting sidelight from a study of the effect of gophers on establishment of a stand of reseeded grasses being carried out in Logan Valley. Here paired plots, one kept gopher-free by trapping and poisoning and the other with no treatment for gophers, were seeded in the spring of 1949 to pure stands of four different grasses. Since there was normally a heavy stand of annuals and spring ephemerals, the treatment preparatory to seeding was moldboard plowing in the spring. Seed was drilled immediately following plowing. As it turned out, the treatment used in seeding prevented attainment of the primary objective of the study because after plowing, gophers apparently moved out of the plots where they were to have been present. The result was that the individual plots of the pairs were all gopher-free. The reason for departure of the gophers appears to have been destruction of the spring-growing perennials by plowing with a moldboard plow. These spring-growing perennials are the principal food plants for the gophers. Following destruction of food plants the gophers moved out with the result that they were not present to damage the newly seeded stands of grasses. It is not known whether this treatment would be effective over large acreages, but this clue is worth following.

The nursery phase of reseeding research is beginning to produce significant results. At the Swauk Nursery on a grassland opening in the ponderosa pine zone of central Washington, 130 strains representing 73 species of grasses, legumes, and shrubs have been tested since 1946.

Ratings in 1949 showed that 54 percent of these accessions rated good or better and 34 percent poor or failures. This would show that there are many species which could be successfully used in similar sites.

Strain differences within species were as striking as differences between species. Slender wheatgrass (Agropyron trachycaulum) strains P-1711 and P-8039 were better than Primar, which is the strain that has proved best in the Palouse country. No appreciable difference was found in production or lateness of maturity between 5 strains of timothy even though Marietta, an early strain, and Lorain, a late strain, were included. No great difference was found in the adaptability of 9 strains of orchardgrass. Two showed a slight superiority but for all practical purposes straight commercial orchardgrass produced as good results as any other strain. With tall wheatgrass (Agropyron elongatum) strain P-5330 was better than P-2326. With intermediate wheatgrass (A. intermedium) P-14 was more quickly sod-forming than P-2327 which in addition to its lower habit of growth would seem to make P-14 a better strain for range seedings. With beardless bluebunch wheatgrass (A. inerme) strain P-7412 was better than Whitmar, the strain found best for the Palouse country. With bluebunch wheatgrass (A. spicatum) the two rhizomatous strains, P-7845 and P-739, proved the most adaptable. With big bluegrass, strain P-8903 was far superior to Sherman which was found superior for the Palouse country. With Canada bluegrass strain P-410, which was proving superior at the Pullman SCS Nursery, was far inferior to straight commercial. With Kentucky bluegrass, no great difference was found among the 6 strains tested even though some difference could be noted in leafiness and date of maturity. Among the 9 legumes tested bramblevetch (Vicia tenuifolia) and birdsfoot trefoil (Lotus corniculatus) look very promising.

In direct contrast to the high degree of success at the Swauk Nursery is the high percentage of failures at the Ray Creek Ridge Nursery which was established in 1945 on the Starkey Experimental Forest and Range. Of the 420 plots in the Ray Creek Ridge Nursery that have been seeded to 78 accessions, only 97 plots in 1949 had a good enough stand to rate above a trace. Only 3 species had no failures on any of the 3 replications seeded to each and for only 9 additional species were there any plots that rated good or very good in 1949. This difference in degree of success can be directly attributed to soil. Both nurseries are on grassland openings within the ponderosa pine zone, but the Swauk Nursery is on fairly good soil whereas the Ray Creek Ridge Nursery is on a typical scab ridge with a shallow, rocky soil almost devoid of aggregate structure and organic matter.

At the Ray Creek Ridge Nursery the 3 species that had no failures were timothy, intermediate wheatgrass, and pubescent wheatgrass. Those species with at least one plot that rated good or better are tall oatgrass, mountain bromegrass, orchardgrass, Canada wildrye, hard fescue, creeping red fescue, prairie junegrass, redtop, and Canada bluegrass.

A third nursery on the fairly good soils of Campbell Flat of the Starkey Experimental area was only established in 1948. Even though there is a much higher percentage of successes in initial stand here than at Ray Creek Ridge, the seedings are too young to have produced any conclusive results.

Some legumes planted in alternate rows with grasses may materially reduce establishment of grasses. This has been shown by a demonstration planting near the Swauk Nursery where sweet clover, birdsfoot trefoil, and bramblevetch were planted in all possible combinations with tall oatgrass, meadow foxtail, and intermediate wheatgrass. Yield data taken in 1950 show that sweet clover definitely reduced the growth of grasses seeded with it. For example, tall oatgrass produced 5,240 pounds of green forage per acre when seeded with birdsfoot trefoil but only 820 pounds when seeded with sweet clover. Sweet clover on these plots produced 8,900 pounds of green forage per acre. Not only is total production of tall oatgrass reduced but its reduced stand is clearly apparent. Intermediate wheatgrass made a better showing than did tall oatgrass when planted with sweet clover. While sweet clover produced a luxuriant growth of 6,300 pounds of green forage on a per-acre basis, intermediate wheatgrass yielded 4,040 pounds. For meadow foxtail (which normally has a slow starting seedling) sweet clover also reduced the first year stand. Where sweet clover yielded 14,160 pounds green weight on a per-acre basis, meadow foxtail yielded 110 pounds. Meadow foxtail planted in alternate rows with bramblevetch yielded 820 pounds green weight on a per-acre basis.

Effects of Logging Studies

Data derived from a system of temporary and permanent transects have shown that logging in the ponderosa pine zone may markedly reduce forage production the first year after logging. These results were released in mimeographed Station Research Note No. 62, and all are embodied in a manuscript being prepared for publication in the Journal of Forestry.

Two valuable items of information found as a result of work in 1950 and as a result of analysis of data collected in previous years are as follows:

Horse and cable logging are much less injurious to forage and soil than tractor logging. This was shown by some data collected in connection with the study of the effect of logging in the ponderosa pine zone on forage production. A comparison of data for the different logging methods is shown in the following table:

Table 1.--Percent of logged pine range disturbed by horse, cable, or tractor methods of log skidding

Log skidding methods	Area denuded of vegetation			Area made inaccessible by slash	Total disturbance affecting forage production and its availability
	Deep skid	Shallow skid	Total skid		
	Percent	Percent	Percent	Percent	Percent
Horse	2.3	9.5	11.8	4.8	16.6
Cable	1.9	13.3	15.2	14.7	29.9
Tractor	16.0	6.4	22.4	8.0	30.4

Horse logging proved the least disturbing to the range with only 16.6 percent of the ground covered by slash or damaged by skidding. Skidding by means of a cable attached to a mobile jammer or by a tractor each disturbed about 30 percent of the ground on the logged areas observed. The lesser degree of total disturbance with horse logging was partially the result of the inability of the horse logger to freely smash through patches of tree reproduction and create numerous and deep skid trails and additional slash. Consequently, the horse logger was confined to a few narrow, well-planned, and oftentimes hand-cleared skid trails.

Slash created by horse logging was relatively small in amount. Slash from the felled timber plus that which the logger cleared from occasional patches of tree reproduction to permit passage of horses covered only about 5 percent of the ground. In contrast, slash on the area where skidding was by cable covered 15 percent of the ground; where skidding was by tractor slash covered 8 percent of the ground. Cable logging created excessive slash because logs were moved in a straight line from stump to jammer. Consequently, any patches of tree reproduction along the way were flattened. Tractor operators, on the other hand, had enough power at their command to be just about as unrestricted in movement of logs as they wished; but there was a tendency in tractor skidding operations for repeated use of at least some of the skid trails. This tendency resulted in less slash-type debris than in cable skidding, but the depth to which the soil was plowed was materially greater--often as much as 2 or 3 feet deep. Deep skid scars more than 1-inch deep covered about 16 percent of the areas where heavy crawler tractors were used in skidding, in contrast to only about 2 percent of the ground where skidding was by horses or cable. Repeated use of the skid trails, action of the crawler treads, and ground skidding were major contributing factors to the amount of deep skid damage observed on tractor-logged areas.

(2) the number of plots per cluster and number of clusters per type; (3) the advantages and limitations of the 3-step method; (4) and a practical system of sampling on a range allotment. The study was carried out on the Flagtail Allotment on the Malheur National Forest, a fairly typical Blue Mountain allotment, well traversed by roads. The total usable range area is 24,000 acres. The three major types with acreages are as follows: open forest - 21,000 acres; sagebrush-bitterbrush - 2,000; meadow - 1,000.

Optimum number of plots per cluster was found to be 2 for the open forest, 2 for the sagebrush-bitterbrush type, and 1 for the meadow. In other words, only in the meadow did the sub-sampling procedure fail to prove more efficient than a strictly random distribution of sampling units. In the case of the meadow, the range in plant density and condition classes was so great that the variation from place to place far exceeded the variation within a cluster area. For example, within the 1,000 acres of meadow type condition classes ranging from a high good to a very poor were present. The other two types had a rather narrow range of variation.

Number of clusters needed to determine the average for the various types within a sampling error of 10 percent were as follows: open forest type - 20 clusters of 2 plots; sagebrush-bitterbrush type - 20 clusters of 2 plots; and meadow type - 50 plots. When change in forage and soil conditions is the primary objective, numbers of plots needed are somewhat different. For a change of 20 percent to be significant at the P .05 level, 22 clusters would be needed in the open forest, 25 clusters in the sagebrush-bitterbrush type, and 20 plots in the meadow.

Soil and forage condition ratings using a score card were found subject to much personal error and are extremely susceptible to personal bias. Consequently, they do not seem sufficiently reliable for detecting trend without being accompanied by some more objective types of measurements such as the line transect. The data secured by the line transect method are much less subjective than those from soil and forage ratings using the score card. Even so, some criteria in the line transect such as the determination of litter and bare ground are also subject to personal bias and need further study to eliminate this serious source of error. The principal source of error in the line transects found in the Flagtail study is the inability to replace lines exactly in the same place.

A 2-man crew seemed to be the most efficient for taking the records, but a 3-man crew would be most efficient for laying out the clusters. Using the number of clusters and plots determined as necessary for detecting change, the time required to lay out the plots would be 21.4 man-days, and the time to record the data and take the photographs would be 28.3 man-days on an allotment similar to the Flagtail.

Big Game-Livestock Relationships

Analysis of the data collected during the cooperative Administration-Research study of big game-livestock relationships from 1945 to 1950 is nearing completion. Very little field work is now being conducted.

From the data on use of range forage by livestock and big game, it is clear that livestock, deer, and elk use many of the same plants. Sandberg bluegrass, on a range used by deer early in the spring and late in the fall, was utilized 50 percent before livestock were turned in. Elk sedge and Idaho fescue are also used appreciably by deer in the spring. In one area where elk were numerous, elk sedge was utilized 50 percent. On spring and summer range both deer and elk utilize many of the important weeds such as hawksweed, penstemon, groundsel, and eriogonum.

Utilization of browse by deer and elk is not confined to winter ranges. During the summer and fall, utilization of such highly important species as mountain mahogany, bitterbrush, snowberry, and willow ranged from 25 to 50 percent. Bitterbrush and mountain mahogany were the most heavily utilized species on the winter deer ranges studied.

Results from clipping studies on mountain mahogany show that complete removal of all current growth for three successive years within 5 feet of the ground level almost completely destroys the ability of the larger bushes to send out new growth in that portion of the bush.

Studies of records from fenced plots from which livestock were excluded but which were supposed to allow free access of big game show that these plots do not give a satisfactory record of big game use. In several locations where such plots were located, livestock were subsequently removed from the adjacent range. In most cases the use on the outside open range was much heavier than in the plot where big game were to have free access. In a few cases the use was much heavier within the plot, but in almost no case were they nearly comparable.

Plans for 1951

During 1951 it is planned to carefully scrutinize all of the existing studies in range reseeding, complete analysis of the data, terminate those studies which are relatively unproductive or from which results are diminishing, and begin some new studies on the more urgent problems. Remeasurement of the permanent transects in the effects of logging studies will be made. Field work of big game-livestock relationships will continue on a much reduced scale pending completion of the analysis of data and preparation of reports. Research on condition and trend will be intensified and procedures used in the Flagtail study will be revised to eliminate, if possible, undesirable sources of error. Grazing studies will be started in the first six

pastures on the Starkey Experimental Forest and Range, and the permanent sampling system will be installed in these pastures. Construction of fences and water developments for the second series of six pastures will continue as rapidly as funds permit.

Plans for 1951 include completion of the following publications and reports:

1. Publication in the Journal of Forestry of a report on the immediate effects of logging.

2. Preparation of articles on the effects of different intensities of clipping on browse species; variation of browse forage production as influenced by climate; and any other worth-while results from the big game-livestock study.

3. Preparation of final report on Big Cow Creek Burn reseeding studies that were begun in 1939.

4. Publication of worth-while results arising from reseeding studies.

5. Preparation of a publication on utilization records collected on the Starkey area.

6. Completion of the range reseeding handbook.

FOREST MANAGEMENT RESEARCH

After four consecutive years of increasing activity the work in forest management research declined during 1950. This was due in part to reduction in funds available, partly to shrinkage in the purchasing power of the dollar, and in part to the return of key personnel to the armed services and to demands for their skills in other work.

Despite these difficulties and diversions, all of the six experimental forests on the national forests--Wind River, Cascade Head, Blue River, Port Orford Cedar, Pringle Falls, and John Day--and the four cooperative experimental forests on private lands--Voight Creek, McCleary, Hemlock, and Hood Canal--were operating. Other test cuttings were in progress on four other experimental areas on national forests--at Henderson Creek, Walker Mountain, Big Creek, and Tar Creek. Several small plot studies were conducted in other parts of the region.

These areas were visited by increasing numbers of private and public foresters, foreign foresters, and forest school students to see firsthand the results of management experiments.

Principal effort continues in the field of applied research. This is supplemented by fundamental studies needed to improve existing hypotheses on how forests should best be managed. Answers being sought are in two categories: (1) those that apply under existing conditions, and (2) basic information needed to guide increasingly intensive management in the future. This year's reduction in activity widened the gap between the current program and that required to provide the basic information needed. Even so, considerable new information was developed and valuable additions to that available are in prospect. Activities during 1950, some of the findings, and plans for 1951 are given below.

Douglas-Fir Second-Growth Management

Interest in Douglas-fir second growth continued to increase in 1950. Second-growth area has been increasing while that of old growth continues to decline. Young-growth acreage now exceeds that of old growth by 64 percent. This explains in part why prices of second-growth stumpage soared during the year. In some instances standing young timber sold at levels higher than the price of second-growth logs delivered at the mill a few years ago.

The Station's Douglas-Fir Second-Growth Management Committee continues to guide the research program in this field. This 10-man group also cooperates in the encouragement, coordination, and publication of results of such research. Late in 1947 the committee assembled existing information on young timber management and distributed it as a Station multigraph "Management of Second-Growth Forests in the Douglas-fir Region." Much destructive cutting in young Douglas-fir has occurred on small tracts whose owners do not have access to services of a professional forester. Thus, the committee next undertook to prepare a nontechnical handbook on second-growth management. This booklet, "Your Trees - A Crop, How to Grow and Harvest Them in the Douglas-fir Region," was printed and distributed during 1950. The publication was financed jointly by the State departments of forestry in Oregon and Washington and by the schools of forestry of Oregon State College and the University of Washington.

The Station is testing on commercial scale of operation, methods of making intermediate harvest cuttings in young Douglas-fir on a stand improvement basis. The area over which such cuttings can be made at a current net profit is steadily increasing. Representative of the opportunities near the best markets are the test cuttings on the cooperative Voight Creek Experimental Forest on lands of the St. Paul and Tacoma Lumber Company some 20 miles from Tacoma. Here on the King Creek area a 29-year-old Douglas-fir stand was given its second commercial thinning within two years. The principal products were smelter poles and sawlogs taken as a selection thinning. Net increment during the two years between cuts was 162 cubic feet per acre or 15 percent greater than in the adjacent uncut stand. A second compartment was added to the test

this year using a crown thinning method in which special effort was made to favor the most promising crop trees in the stand. The material cut in this operation averaged only 7 inches in diameter and consisted largely of smelter poles, car stakes, and corral poles. Owing to the small size of material handled, the operation which removed only 92 cubic feet per acre resulted in a small current loss. An additional 50 acres was thinned on 3 compartments in the 39-year-old Douglas-fir at Voight Creek. Light and medium thinnings were made and uncut check areas established for control. Cut per acre ranged from 578 cubic feet or 11 percent of the total to 1,780 cubic feet or 39 percent of the original stand. Average cut per acre was 1,229 cubic feet or 25 percent of the total. Products valued at $174 per acre loaded on trucks were removed as follows:

Product	Cubic foot volumes		Percent of total removed
	Total	Per acre	
Logs	33,659	673	54
Smelter poles	24,374	487	39
Car stakes	1,877	38	3
Fence posts (cedar)	2,356	47	4
Total	62,266	1,245	100

Production per man-hour averaged 12.35 cubic feet. This was an improvement of 34 percent over the block previously thinned, realized through raising minimum tree diameter to 8 inches and by improved crew organization. This project shows that it is possible to log very young timber under good forest management practices, and that the returns are sufficient to pay all operating costs and leave a margin for profit and stumpage.

The McCleary Experimental Forest on lands of Simpson Logging Company is being developed and maintained entirely from proceeds from timber removed in the first cut. During the year additional roads were constructed and the light-to-moderate stand-improvement thinning program was continued in the 50-year-old site II Douglas-fir stands. A total of 328 M board feet of logs was removed from 45 acres, which is 16 percent of the original volume. A part of this forest has been set aside as a demonstration tract for farm wood lot owners. Some timber will be harvested under good silvicultural practices from this "Farm Forestry 40" each year. This year the second cut was made on this test area, a total of 52,800 board feet being removed from the 8-acre compartment set up for this year's harvest.

A management plan was prepared for the new Hood Canal Experimental Forest and the first test cuts covering 125 acres completed. Volume per acre removed from this 60-year-old Douglas-fir averaged 4,000 feet per acre or 16 percent of the original. This cutting was made as a commercial sale to an independent logger at a stumpage rate of $4 per thousand.

First test cuts were made on the new Hemlock Experimental Forest in cooperation with the St. Regis Paper Company. This preliminary cutting, removing the old remnant hemlocks left by the original logging about 40 years ago, took a total of 63,000 feet of hemlock saw timber, 11 cords of pulpwood from the 50-acre compartment. Although the total harvest amounted to an equivalent of less than 2.5 cords per acre, this also was conducted as a commercial sale. The stumpage return amounted to $10.54 per M for the sawlogs and $1.75 a cord for the pulpwood.

Two intermediate harvest cutting experiments were under way in 70- and 75-year-old Douglas-fir stands on the Snoqualmie and Olympic National Forests. The poorer quality, more defective trees in the stand were cut; 12 to 16 percent of the total volume was removed through regular timber sale procedure.

The logging operator on the Walker Mountain area invented an ingenious tree shield made from discarded oil drums. This device has been very effective in protecting trees along roads and near landings from basal injury. An article describing the device was prepared and submitted to the Journal of Forestry for publication.

At Panther Creek on the Wind River Experimental Forest a 3-million-foot experimental cutting in 110-year-old Douglas-fir was about half completed. This stand is rather seriously infected by Poria weirii root rot and one of the objectives of the study here is to discover better indicators for trees infected with this root fungus. Work is being conducted in cooperation with the Office of Forest Pathology in the Bureau of Plant Industry. The pathologists have developed the hypothesis that Poria weirii is more prevalent in pure stands of Douglas-fir that have succeeded pure stands of this same species. This indicates the desirability of converting pure stands to mixed stands on infected areas. The tests at Panther Creek call for the introduction of Western hemlock and grand fir on the cooler slopes and of ponderosa pine on the hotter, drier slopes. They include both clear-cut regeneration settings and stand-improvement partial cuttings. The clearcuts are located in the understocked, brushy areas, those most in need of regeneration, and cover a range in sizes to determine the most effective dimensions for prompt regeneration and practical operation.

During the year three reports were prepared by Matson dealing with the recovery of lumber from young Douglas-fir timber. These reports consisted of (1) Research Note No. 70, "Fall Creek Second-Growth Douglas-fir Thinning Study," (2) "Second-Growth Douglas-fir Lumber," which was presented at the Pacific Northwest Section meeting of the Forest Products Research Society meeting at Shelton, Wash., and (3) "Lumber Grades and Costs from Second-Growth Douglas-fir" that will be published in The Timberman magazine. These studies show that young Douglas-fir timber studied produced at least 80 percent No. 1 Common or Better lumber and that practically all logs 12 inches or larger in diameter should have been graded as No. 2 Sawmill logs.

Many Douglas -fir stands have now had their first thinning on both private and public lands; few, if any, have had successive thinnings on commercial scale and have careful records of costs, returns, and the growth rate per acre before and after cutting. Two of our thinning experiments on the Olympic National Forest now provide such records, one at Mt. Walker, the other at Kugel Creek. These tests were started in 1937, and since that time three measurements of growth and two thinnings have been made.

Trees in the Mt. Walker plot were 60 years of age at the time of the first thinning and averaged 77 cords per acre before the cut. Approximately 25 cords per acre were removed from this site IV stand. A second thinning was made in 1949, at which time the stand averaged 70 cords per acre of which $5\frac{1}{2}$ cords were removed. Periodic annual growth in the thinned area was 1.6 cords while in an adjacent untouched check plot it was 1.5 cords.

Similar results were obtained on the site III Kugel Creek plots. This stand, 38 years old just before the first thinning, averaged 67 cords per acre, of which approximately 23 cords were removed. Twelve years later the stand averaged 81 cords per acre, of which 13 were removed in the second thinning. Periodic annual growth was 3 cords per acre, which was slightly higher than obtained on an adjoining uncut check plot with much heavier volume of growing stock. Increment in the thinned area is being laid on the highest quality trees in the stand. A report on this project was prepared by Worthington and Isaac and presented at the Northwest Scientific Association meeting in Spokane on December 28.

Large-scale cutting experiments in 100-year-old spruce-hemlock stands were continued on the Cascade Head Experimental Forest. These cuttings are designed to test and demonstrate the most promising forest management techniques and at the same time provide areas where fundamental study installations can be made that will yield basic silvicultural information in the future. Sale unit No. 5 was made in February 1950 to Publishers' Paper Company. Logging of this unit will be completed in January 1951 with the cut estimated at approximately 8,250,000 board feet.

During the past three years 12 staggered settings have been clearcut at Cascade Head, totaling 261 acres, on topography too rough for improvement cuts. These settings range in size from 2 to 81 acres. They provide areas of different sizes and shapes where basic seedfall, regeneration, windfall, erosion, slash burning, logging cost, and other studies have been established. Continuation of these studies, together with cost studies of the logging operation, will provide basic information for a careful evaluation of the staggered-setting system in the spruce-hemlock type. Intermediate cuttings have been made at Cascade Head on 9 unit areas totaling 390 acres. Permanent growth and mortality plots have been established in the partial cutting areas and in adjacent check areas. Periodic remeasurements will provide such information as growth, mortality, response to release, effect of soil disturbance, decay,

and windthrow. Successive intermediate cuttings will be made on these areas when growth and mortality data indicate they are needed, probably at 5- to 10-year intervals. Special efforts are being made to develop and test falling and yarding techniques and utilize equipment that will minimize logging damage to the soil and to the residual stand. Various intensities of repeat cuts are contemplated to determine the optimum amount of growing stock from an economic and silvicultural standpoint, proper species selection, marking rules, and best length of rotation.

A comparison of the costs at Cascade Head on the first two cutting experiments is of interest. A total of 12 million board feet of logs was yarded by high-lead methods. Cost of falling, bucking, and yarding averaged $19.71 per M. Using tractor yarding in light partial cuts, the cost of these same operations in logging about 3½ million feet was $21.21 per M. Horses were used in logging about 600,000 board feet of logs from a light sanitation-salvage cut. Costs of putting these logs onto trucks was $16.60 per M. All costs are based on net water scale except for the horse logging where truck scale was used. Although not enough studies have yet been made to state definitely the costs of logging by the various methods, the work to date does indicate (1) that cost of making improvement cuts is not much greater than for high-lead clear cutting, and (2) that on gentle topography cost of horse logging of small material compares favorably with that done with tractors.

Loss from windfall is one of the serious problems in the management of the spruce-hemlock type. Windfall hazard is great along the coast as the trees are shallow-rooted and the ground is saturated with moisture at the time of the heavy winter coastal storms. The problem is most critical around the perimeter of the clear-cut settings. An attempt is made to locate cutting boundaries so windfall will be minimized. Accurate records are maintained on amount and cause of windthrow. During the three-year period that we have logged 261 acres in the 12 clear-cut settings, we have lost 307 trees by windfall. Seventy-nine percent of the losses were from uprooting and 21 percent from trunk breakage. All but one of these trees fell from the edge of the clear-cut opening into adjacent timber. Eighty percent of the trees fell toward the north or northeast, indicating that south and southwest winds were responsible. Southerly storm winds apparently dip down into clear-cut openings even on north slopes with sufficient force to throw the exposed trees that had previously been protected by the timber that was logged. Results to date indicate cutting boundaries should be located in sheltered places, particularly the northeast boundary, logging should progress windward whenever practicable, cutting boundaries should avoid moist soils, swampy ground, and narrow gaps that will increase wind speeds.

At times it has been difficult to get satisfactory research results in applied forest management cuttings through regular timber sale procedure. Therefore, a test of handling this work at Cascade Head through cooperative agreement is being made. Such an agreement has just been drawn

up with the Publishers' Paper Company which is expected to facilitate the test cuttings under way. A detailed logging plan for the timber to be cut during 1951 has been laid out on the ground and a working plan prepared. The 1951 cut includes 4 high-lead settings, 1 tractor clear-cut, and a 79-acre intermediate cutting. A combination tractor-horse yarding system will be used for the intermediate cut. This is designed to minimize damage to the soil and the residual stand by using horses for bunching and to extend the total yarding distance and reduce costs by using a tractor to swing the logs down main tractor roads.

Douglas-Fir Region Old-Growth Management

Intensive small-plot studies, extensive examinations of stands and cuttings over the region, studies of logging costs and of timber values have been under way in the Forest Service for more than 40 years. From these have been developed an increasingly detailed system of hypotheses on how the virgin forest should be managed to yield maximum continuing benefits. During 1950 some of these principles were outlined and issued as Research Note No. 71, "Applied Forest Management in the Douglas-fir Region." Detailed methods of applying the management principles are described in the companion Research Note No. 72, "Suggestions for Getting More Forestry in the Logging Plan" by Ruth and Silen.

Systematic, commercial scale cutting experiments in Douglas-fir region old growth were in progress on three experimental forests during 1950 to test and to improve the promising management principles. A 9-million-foot test cutting at Wind River was almost completed during the year, as was a 4-million-foot experimental cutting series at Port Orford Cedar. The initial 24-million-foot series of cutting tests at Blue River was about at the half-way mark at year's end. Two other cutting experiments were in progress on the national forests; an 11-million-foot series at Henderson Creek on the Siuslaw was almost completed; a somewhat smaller test at Tar Creek on the Mt. Hood was started.

Most remaining old-growth timber in the Douglas-fir region is located on rough topography, making high-lead logging necessary which in turn necessitates clear cutting. However, there is some gentle topography, perhaps 25 or 30 percent of the total, suitable for present methods of tractor logging. Light stand-improvement partial or salvage cuts prior to clear cutting for regeneration later may increase the total harvest from some of these areas. Thus, partial-cut settings have been included in our old-growth experiments to determine the effects of such cuttings. On some units an attempt is being made to favor a hemlock understory and bring it to merchantable size before regeneration by clear cutting.

Due to rough topography, road and logging costs for old-growth Douglas-fir are high. It is, therefore, important in the staggered-setting system now being employed that roads, landings, and cutting

boundaries be properly located both for present units to be cut and the leave settings. To minimize costly errors, it is necessary that a detailed logging plan be made, prior to any logging, of a drainage or logging unit giving consideration to both cut and leave settings. Thus, detailed forestry-logging plans have been made on all cutting experiments. On such jobs consideration should be given to all phases of forest management, economics, engineering, silviculture, fire protection, and watershed management, balancing the needs of one against the other in the planning of each cutting unit. Decisions must be made for every setting, both cut and leave, so that the initial road system serves all of the timber to the best advantage. The area must be intimately known before these decisions can be made. Costs for making these detailed logging plans and layout have been kept during the past three years and amount to 12 cents per thousand board feet for the timber logged in the first cut. However, based on the total timber volume covered by the plan, the cost is only $2\frac{1}{2}$ cents per thousand. See Research Note No. 72 for recommended procedure of doing this job.

Research on the Blue River Experimental Forest is aimed at obtaining answers that apply in managing an entire drainage or working circle. Watershed management studies are an integral part of the work. Operational-sale tests of how logging affects erosion and stream flow are included in the program. Plans were completed this year for a watershed study of three matched small drainages. Stream gauge sites were chosen, maps of these sites made, and a road was constructed into the most remote of the three gauge sites. Gauges will be installed next summer. After a calibration period of about six years, it is planned to log two of the drainages, one by clear-cut methods and the second using the staggered-setting principle and to compare the stream flow and erosion that follows with that on the third drainage left in virgin condition.

Study of the going cuttings indicates that most of the stream sedimentation came from road building and road use. In logging, the main damage resulted from operation of heavy equipment during periods of surface runoff. Previously logged areas were important sources of turbidity only during the heaviest rains, in which case even the streams coming from virgin forests were somewhat colored. Soon after any appreciable rainfall the ditchwater from any road in use became turbid, and this was at all times one of the main sources of turbidity. However, good drainage of the roadbed using a man with a shovel during heavy rains, plus good previous crowning with a grader, was effective in greatly reducing this source of sedimentation. Draining of ditch water across settling basins or onto the forest duff likewise greatly reduced the sediment reaching the stream.

Road layouts on Blue River Experimental Forest are being planned to keep sediment reaching streams to a minimum. Special effort was made to avoid dumping of fill material into streams during road construction. Building of roads in rainy weather was found to be a major source of

sediment. The runoff from heavy rains was diverted down new grades, sometimes purposefully to wash the fine material from the new exposures of gravel. This practice was found to be a major source of damage to water quality and sedimentation in stream courses.

Landings were planned to avoid yarding across streams. In the few cases where this could not be done, the bringing of dirt and debris into streams with the logging from the opposite bank was an important source of sedimentation, even in dry weather. In wet weather damage to the soil from this source was even greater because stream banks were soft and fresh; raw drainage patterns were set up in the skid trails. This can be especially serious on tractor-logged ground, since practically all the surface water is channeled down the fresh soil of the tractor roads unless special efforts are made to divert the water elsewhere. Preliminary tests indicate that sedimentation resulting from road building and logging can be reduced greatly by:

1. Planning the roads and cutting units to prevent excessive dumping of soil into stream courses, large or small.

2. Preparing for heavy runoff in advance by proper crowning and drainage of roads, and the prevention of excessive drainage down skid-trails through use of water bars and diversion ditches.

3. When heavy runoff begins, a few hours of work with a shovel to prevent water from washing long distances down road ruts, across landings, and down skid trails is effective and inexpensive.

4. Suspending operation of logging equipment when surface runoff is so great that excessive sedimentation cannot be prevented by such cheap maintenance measures.

One cutting unit was logged to the banks of Lookout Creek to test the effect of streamside treatment in logging under four possible alternatives. The west edge of the unit is a test of the cost and value of leaving a wide strip of timber between the first road level and the creek. The east edge of the unit is extremely steep, and here the trees were felled to the creek bank to test the problems of streamside logging on extremely steep ground. Bordering the steep ground is a 250-foot stretch of streamside having gentle topography which was also logged to the stream bank. Probably at some point between the gentle and steep topography some conclusion may be reached as to the gradient beyond which logging along streams cannot be done without serious damage. As a fourth alternative a narrow fringe of trees was left on a part of the streamside as a test of the costs and values of leaving such a strip. All logging was done by high-lead, uphill away from the stream. Conclusions at the end of the first year are that the stream was not seriously affected by any of the alternatives either in terms of increased turbidity during and after logging, or in terms of the accumulation of logging

debris. Even on ground as steep as 85 percent, with a very narrow bench at the bottom, few logs reached the stream in felling. Subsequent clean-up left the stream bed with less debris than had existed under virgin conditions. Observations will continue regarding erosion and regeneration problems in this test.

Pine Management

The major activity in pine management in 1950 was the establishment of two experimental cuttings, one at Pringle Falls and the other on the John Day Experimental Forest. These are designed as first-step treatments in the conversion of old-growth ponderosa to thrifty, managed stands.

At Pringle Falls approximately 3,500 acres were covered in a sanitation-salvage cutting of about 5 million feet--an average harvest of only 1,400 feet per acre. Preliminary figures show the cost of sale layout, road locating, timber marking, and supervision for this very light cut averaged about 45 cents per M board feet. This is 15 cents higher than the average when a 40-60 percent instead of a 10 percent cut is taken. But previous studies show the reduction in mortality over the whole forest per M board feet cut is five times as great under sanitation-salvage as it is under the heavier cut. At prevailing stumpage values the greater saving in mortality in the first year amounts to several times the additional cost of sale administration. Tests show this beneficial effect continues for at least 12 years after such cuts. Detailed logging-cost records are being kept for this operation, and indications are that costs per M are not much higher than where heavier volumes are removed. The current stumpage price for this light cut is $26 per M.

Objectives of the first-step sanitation-improvement cut for conversion to managed forests at John Day where insect risk is lower and the species other than pine more abundant were: (1) reduce losses occurring in all species by harvesting low vigor trees, (2) maintain a high growing stock of best possible quality in pine, (3) increase the pine percentage in the stand, (4) improve stem distribution, and (5) establish a road system that will serve future cuts and be easily maintained. The volume harvested averages about 6,000 board feet per acre of which about 4,000 is species other than pine. This is being contrasted with current cutting practice in this same stand, which removes about 8,000 board feet per acre, of which less than 2,000 board feet is in the associated species. A total of 3 million feet is being harvested in this test. Stumpage return for the pine is $23 per M, for the other species $1.30 per M. This contrast in value illustrates why efforts are being made to maintain a favorable percentage of pine growing in the stand for future harvest.

Ponderosa pine needle blight (Elytroderma deformans), now causing much mortality in the pine stands of this region, has reached epidemic proportions on the John Day Experimental Forest and surrounding areas. A cutting was made this year in the infected area primarily to salvage dying trees. Plots have been established in the area in cooperation with the Office of Forest Pathology, Bureau of Plant Industry, to obtain data on how to identify infected trees and how to determine seriousness and trends of this infection.

Neglected in the Station's program of management studies are the complex southwestern Oregon mixed conifer types. Exploratory studies made during the year in the Umpqua and Rogue River areas revealed large acreages in these types on some soils producing mostly low quality Douglas-fir at a slow rate of increment. But in these same stands, occupying a small proportion of the total area, ponderosa pine is growing quite well, and sugar pine is growing both rapidly and to exceptional quality and value; with Douglas-fir stumpage here selling at about $10 per thousand board feet; sugar pine of the same age and grown on the same soil was selling at three or four times this rate. The prospect is good that volume of timber yield as well as value per unit of volume can be greatly increased by increasing the proportion of sugar pine in the stand. What is needed now is to test the practicability of various methods of logging and follow-up cutting-area treatment designed to accomplish this. Last summer plans were laid to designate a portion of the South Umpqua area as an experimental forest to make such tests on a commercial scale.

Plans for Management Studies in 1951

Plans for the coming year are to continue with large-scale cutting experiments on the Blue River, Cascade Head, and Wind River Experimental Forests and to continue the long-term cutting tests in progress on the four cooperative experimental forests in young Douglas-fir and hemlock. Cutting studies in progress on the other experimental areas should be completed during the coming summer, and major emphasis will then be given to analysis, compiling and reporting on completed work, and on completion of study installations. A project on tree poisoning to reduce log weights and facilitate bark removal will be started at Cascade Head. Cost of hauling logs from that vicinity to markets on the Willamette River approximates one-third of the total logging cost. If the weight of logs per cubic foot can be reduced, substantial savings can be made. Also at Cascade Head tests will be made of poisons and poisoning techniques for destroying the heavy brush common to moist areas in the coastal type, thus facilitating prompt coniferous regeneration. Poisoning will be tested in combination with slash burning and planting.

Reports summarizing and analyzing detailed cost data on completed sales will be published during the year.

Light sanitation-salvage cuttings in ponderosa pine under way at Pringle Falls appear to have much promise. The plan is to give this

system further test under different conditions in cooperation with the national forests on two to four other variations of the pine type during the next two years.

Regeneration Studies - Natural and Artificial

Natural regeneration. Seed dissemination studies last year were installed in Douglas-fir second growth, spruce-hemlock, ponderosa pine, and Port Orford white-cedar by the use of seed traps. The resulting data, now in the process of being worked up, will be correlated with the occurrence of established seedlings in different-sized openings and at varying distances from timber edge and other factors of site. Included in the study is a test of seed trap sizes. It was found that a 1-square-foot, all-screen trap caught slightly more seed per square foot than the 6-square-foot cedar and screen trap but was less desirable because of difficulty in relocation and maintenance.

A new approach to natural regeneration consists of poisoning rodents in an effort to save for germination more of the natural seed fall when crops are medium or light. Light and medium crops normally are almost completely consumed by rodents. If this population can be eliminated, medium or even light seed crops may contribute effectively to regeneration. From the heavy seed crop of 1949 large amounts of seed were caught, numbers ranging from a half million per acre in pine to several million in the fir region (11 pounds per acre of mixed species on one area and 28 pounds on another at Wind River). As a result, regeneration is well established on fir region test areas. But the half million pine seeds on the Fremont produced only 120 seedlings per acre on burned surfaces and less than 100 on tilled and natural surfaces after an attempt to poison rodents on the area with strychnine-treated grain.

Research Note No. 73, "Seed Crop Prospects for 1951," with photos of winter flower buds, was prepared in December to help evaluate next fall's seed crop for use in preparation of cutting, slash disposal, and seed collecting plans.

Preliminary study of the reproductive characteristics of Port Orford white-cedar was started this year. The results show that promptly burned and unburned clearcuts are much better restocked and with a higher percentage of cedar than are partial cuts or clearcuts reburned.

An interesting discovery was made in connection with seed fall studies. Abies seed which fell on deep snow germinated on the snow banks in the spring. No seedling that germinated in this manner was found to survive. Hemlock, cedar, and Douglas-fir seed were found on the snow also, but they did not germinate until the snow was gone. This warns against hazards of sowing Abies on deep snow.

Artificial regeneration-seeding. A seed storage study in cooperation with the Boyce Thompson Institute is now in its fourth year. Except for western redcedar where some difficulty has been experienced, all species have kept well at temperatures of 21° F. The test of cedar is being repeated and other species included in tests at temperatures down to 0° F. Experience in the Division of Timber Management has shown seed holding its viability at temperatures as low as 0° F., for periods up to 10 years. Both fir and pine are stored that way at the present time.

Last year in cooperation with the Gifford Pinchot National Forest, where a rodent poisoning and broadcast seeding of several hundred acres was being made, replicated tests were put in using different amounts of seed varying from a quarter of a pound to two pounds per acre, and tests were made of spring and fall sowing. Preliminary examinations indicated less than 300 seedlings per acre even with heavy sowing. Final figures will be obtained as soon as snow leaves in the spring.

Encouraging is the assignment in 1950 of an added man to the field of rodent control by the Fish and Wildlife Service. He has worked with the men at the Wind River Experimental Forest in establishing tests of different poisons for the control of seed-eating rodents. Other phases of the rodent problem being studied are: (1) the effectiveness of poisoning at different seasons of the year and under different natural food conditions on the ground, (2) the comparative effect of poisoning a broad control strip as compared to establishing a control "barrier" of permanent bait stations around treated areas, (3) a comparison of traps with acceptance spots to measure rodent population, and (4) further search for rodent repellents.

At Henderson Creek and at Wind River the staking and checking of hundreds of broadcast sown seed are giving a measure of what happens to such seed. At Wind River a quarter of the staked seed sown in June had disappeared by October, while at Henderson Creek seed sown in March had three-fourths disappeared by fall. However, only a few of the June sown seeds at Wind River germinated while most of the seed remaining at Henderson Creek produced seedlings. Timing appears to be an important factor in the sowing of stratified seed; the sowing at Wind River was probably too late.

After several years' tests, the pelleting of tree seed appears to have no particular advantage over the use of bare seed, except for possible use in a hand planter where pelleting of the smaller seeds may make it possible to plant individual or accurately spaced seeds. A completely satisfactory hand planter for the planting of one seed at a time has not yet been developed, but improvement of our present experimental model will be attempted.

Tests of spot and broadcast seeding with ponderosa and sugar pine, with and without rodent poisoning, during 1950 in southwest Oregon, gave

no promising results, largely because rodent poisoning was not effective and seedling mortality was high. In sod patches available soil moisture was gone to a depth of 30 inches by September 1; in the open the soil was moist below 6 inches in depth. "Keyes screens," in which seed is packed in soil in a small screen cylinder designed to protect both the seed and seedling against rodents and insects, were given preliminary test by the Station for the first time this year. Results were not very encouraging. Tests will be repeated with variations in 1951.

Planting. Studies of prompt planting after cutting were continued on areas where there is danger of brush taking over before natural regeneration can become established. Some of these are now in their second year at Henderson Creek and at Cascade Head Experimental Forest, and the results are now being compiled.

A test of the fill-in planting with different grades of Douglas-fir planting stock on brushy areas, where natural restocking is not adequate, was installed at the Hemlock Experimental Forest.

Port Orford white-cedar has enjoyed considerable popularity as a species for planting outside its natural range. These plantations have in spots made excellent growth and development, but on the whole apparently have not quite equaled some other native conifers. For that reason a field examination was made of more than a dozen of the important older plantations in different parts of the region to determine under what conditions of climate, soil, and exposure Port Orford white-cedar made satisfactory or best growth. Indicated favorable conditions are: well-drained slopes with abundant moisture and no overhead shade.

A tenth-year report was prepared for a test of 11 classes of ponderosa pine planting stock raised from the same seed. Transplants averaged slightly better than seedling stock, but results were not consistent. Out of the six best lots (survival 68 to 82 percent) two were seedlings, and one of these was third from the top. This illustrates that well-developed stock of either transplants or seedlings can produce an acceptable plantation.

For some years there has been unexplained mortality in both pine and fir plantations. Some planted seedlings die promptly, others manage to stay alive for a year or so and make little or no growth and finally succumb. An examination of several problem plantations on the Olympic, Willamette, and Deschutes National Forests revealed that most of the roots were dead and that new growth was started on only a few seedlings. Plantations on another area, or made at a different date but using the same planting stock, have made satisfactory survival. To probe for the cause of this mortality a preliminary study was started in cooperation with the Division of Timber Management and the Deschutes National Forest. Proportional parts of the root buds were removed from different logs of seedlings. Moss versus shingle tow is being tested for the

packing of planting stock. A commercial product known as "Transplantone" to stimulate root growth was also tested. Differences were noted but not great enough to be significant between these treatments. However, when the liquid was taken from the tank where shingle tow was soaked and seedling roots soaked in this liquid for three hours in the same manner that the Transplantone was used, 33 percent of these seedlings survived but made very poor growth while 90 percent of the normal seedlings and 96 percent of those soaked in Transplantone survived. This indicates that shingle tow may not be a satisfactory material to use under all conditions in the packing and shipment of seedlings from the nursery to the field. Further tests are planned to determine if under certain conditions or treatment this material injures roots.

Where root dying was noted on Douglas-fir planting stock this fall, an exploratory test was made on the Willamette National Forest, planting a second lot of seedlings with sound roots beside a first lot with roots in poor condition.

Visiting foresters in 1950 from all European countries, except Spain and Iron Curtain peoples, through their inquiry and comment further accelerated interest in benefits to be derived from securing the best seed for a given site. While the national forests and most other agencies in the region are attempting to obtain their seed from sites that are climatically comparable to the planting area, there is good prospect that more intensive selecting of superior stands and superior individuals for a seed source would pay large dividends. Further tests of seeds from different sites are planned in cooperation with representatives of European countries who use our species in planting. Some seed has already been collected from superior sites at higher elevations than better stands normally occur. Site I growth and site IV growth have been found on areas not far apart, soil being the chief difference in site. Lots of seed from such stands will be tested on neutral sites to determine the influence of these growth characteristics on the progeny.

Stand Improvement Studies

Pruning. Plots at Wind River from which different portions of the live crown were removed by pruning received their twelfth-year examination last summer. Field observations indicate that one-fourth of the live crown may be removed without loss of growth, entrance of decay, or other depreciating effects. Results of pruning and growth studies made over the years were summarized this year in a manual, "Financial Aspects of Pruning." This publication gives tables and examples showing prospective returns from different initial costs and different interest rates, and indicates where pruning is likely to be a profitable investment. Two exploratory studies related to pruning were made. "Peeler Potential for Southwestern Oregon," published in The Timberman, indicates that 2 million acres will be required to grow material for high-grade plywood in the five southwestern Oregon counties,

and that crop trees will have to be pruned in these stands. The other report, "Shall We Prune to Provide Peeler Logs for the Future?", shows that trees pruned at an early age will produce twice the amount of clear wood at normal rotation age as will unpruned trees in natural stands. This article has been submitted for publication in 1951.

Liberation studies and premerchantable thinnings. Work is continuing on the national forests in the use of herbicides and release cutting to liberate forest plantations and natural regeneration from competing brush and broadleaf growth such as alder. Results have been variable. Vast areas, some of them very highly productive, have been taken over by brushy growth. The reclaiming of these lands is one of our major unsolved and inadequately studied problems.

Pine foresters are familiar with the frequent occurrence of overdense ponderosa thickets in the understory of the virgin stand. Characterized by poor thrift and extensive mistletoe infection, prospect of growing rapidly into valuable merchantable stands is poor. To determine the effects of stand improvement thinnings in such problem areas, a systematic thinning study was started this year in cooperation with the Deschutes National Forest. Factors being tested are degree of release given, spacing of crop trees, and effect of overwood on growth of the sapling stand. One of the puzzling problems needing study in this connection is the selection of the best crop trees. Indications are that a dominant tree at time of treatment may not remain dominant; if it does not, money spent in pruning it or giving it release may be spent better on other trees. Proposed indicators of poor risks for crop trees are abnormal reduction in current leader growth, thinning out and unhealthy appearance of the crown, severe mistletoe infection, excessive dead and dying limbs, and excessive lean. The relationship of such characters to subsequent growth of sapling pine crop trees is proposed for future study in cooperation with east-side national forests.

"Cutting Lodgepole Overstory Releases Ponderosa Pine Reproduction" is the title of a report by Mowat published in the Journal of Forestry this year. It shows that ponderosa released from overtopping lodgepole grew in height from four to five times as fast as unreleased trees.

Forest Soils Studies

The program of forest soils research was interrupted in October when Tarrant was recalled to active military duty. Needed expansion of this work was thus set back, but good progress was made on the studies under way.

Carmean completed field work on the study of soil factors related to site and growth rate of Douglas-fir and at year's end returned to Duke University to carry on the laboratory analyses and computation of results. Field work on this project would not have been completed this

year without very effective help in data collection given by members of the Washington State Supervisor of Forestry's staff.

A soils map of the Hood Canal Experimental Forest near Port Gamble, Wash., was made and a report prepared on the soil characteristics likely to affect management practices on the tract. Value of soil surveys as a basis for planning cutting operations was emphasized by the discovery of a high windfall and roadway erosion hazard over much of the forest due to a soil hardpan. Indication is that thinnings must be very light and road standards high on such soils to avoid damage to both stand and roadways. The new detailed map will also permit study of relation between soil types and site. Such study on the Voight Creek Experimental Forest indicated that the presently used soil classification units are inadequate for a close measure of the productivity of a given area and that a more meaningful system of forest soil classification than that presently used is necessary in this region.

Soil conditions under Port Orford white-cedar plantations were studied along with other factors of site by George James. Complete soil profile and site descriptions were taken at each of some score of Port Orford white-cedar plantations included in the study. The purpose of this study is to determine soil and site conditions favorable for the growth of Port Orford, both within and outside its natural range. This work was also a casualty of the national emergency when James was recalled to active duty in the Army in October. Analysis of these data will be completed when qualified help is available.

The effect of a sawdust mulch about planted seedlings was tested in the dry, infertile pumice soils of the Deschutes Plateau. No significant effect of the mulch in terms of ponderosa pine seedling growth or mortality was noted in the first-year examinations. However, when the surface soil temperature was 136° F., the soil temperature at 3 inches below the surface was 92° beneath the unmulched trees and 78.6° F. beneath the mulch, or 13.4° F. cooler. Further tests should show whether the mulch has significant effect on survival and increment in a more critical season.

A test also was made of the use of commercial preparations containing Beta-indolebutyric acid, as a possible stimulant to the formation of adventitious roots on ponderosa pine planting stock. If these substances can stimulate more rapid rooting of planted seedlings, better survival may be obtained in the dry soils where moisture lies deep during the summer. Results of this test showed slightly higher survival and slightly better leader growth of the treated seedlings. Further tests are recommended with the thought that important differences may occur in less favorable growing seasons.

Effects-of-burning studies were continued with periodic examinations of the Douglas-fir slash study plots. After two years the indication

is that light burning raises the pH only slightly above normal and that the effect is quite temporary. However, where fire was hot enough to burn all organic material and turn the soil to reddish-orange hues, the pH has been raised to a strongly alkaline point, from which the return to the normal, moderately acid state is extremely slow. The effects of known temperatures and duration of those temperatures were studied in the laboratory for representative forest soils of the region. It was found that soil reaction rose toward strong alkalinity in fairly direct proportion to the temperature and duration of heat up to about 1,200° F., at which point the increase in pH leveled off. Different soils were found to have different reactions, some rising to much greater alkalinity than others. Germination tests of Douglas-fir seed were made in connection with this study, using selected soils to give a range from strongly acid (pH 4.5) to strongly alkaline (pH 8.8) reaction. Germination was not found to be affected by this wide range in soil reaction. Both the lowest germination (50 percent) and the highest (68 percent) being noted on soils at pH 5.5, and no correlations were evident.

A study of the foliage nutrient content of representative Pacific Northwest forest trees was completed this year. As a part of this study, begun in 1941 in cooperation with Dr. Robert Chandler now at the University of New Hampshire, the content of major nutrient elements contained in foliage was measured. Annual leaf and needle fall of the several species has also been measured to provide an estimate of the fertilizing quality of the various cover types of the region. Red alder foliage was found to contain extremely high amounts of nitrogen compared with the other species. Bigleaf maple and red alder contained very high amounts of potassium compared to the conifers, and western redcedar and maple contained very high amounts of calcium compared to the other trees. The study indicates that alder, cedar, and maple may be of special value as soil building species.

A start in collecting soil management data for southwestern Oregon was made this year when a reconnaissance of major soil and geologic types of the area was completed. As a result of this work, studies of the erosion potential of the major soil groups have been started under the supervision of the Division of Flood Control Surveys of the California Station, which is charged with flood control study in this area. It is hoped that a system of erosion hazard rating for the various soils can be devised to assist forest managers planning culvert, grade, and other specifications in road construction and logging layouts.

Forest Mensuration

Demands for the products of volume, growth, and yield studies reached a new high during 1950. Stumpage prices increased as timber supplies in the open market declined. Foresters are under new pressures to determine accurately present wood volumes and to estimate the supplies to be available from increment in the future. The levels at which an

increasing number of forest industries operate depend upon their calculations. Still lacking a mensuration project leader, the Station's program in this field declined while the need for results increased. Dr. George Barnes of Oregon State College, who has made valuable contributions to the Station's program in past summers, could not be employed this year because funds were not allotted until after the field season had passed. This delayed for another year completion of the new western hemlock yield tables, already in preliminary draft. Floyd Johnson, formerly of the Forest Survey staff, who has worked part time on mensuration studies in recent years, was transferred to the Washington Office for defense work during 1950 and was not replaced. To keep up with the tasks of plot maintenance, the interval between examinations has been lengthened. Even so, re-examinations of some 27 plots in the Douglas-fir, spruce-hemlock, and ponderosa pine types came due and were completed within the year. Staebler continued the study of growth of young Douglas-fir by tree class while on leave for graduate work at the University of Michigan. Dahms, on leave for advanced study at Syracuse University, is investigating the effect of growing stock levels on ponderosa pine increment.

Some studies started in previous years paid off in the form of useful results. For example, little information has been available previously to show foresters how many trees they should measure to determine site quality within desired limits of accuracy. A paper by Johnson and Carmean, "Sampling Error in the Estimation of Site Index," submitted to the Journal of Forestry during the year, proposes to do just this for those working with Douglas-fir. An example from the findings is given in the following table:

Number of site determinations per area	Limits around estimated average site index within which the true site index may be expected unless a 1-in-20 chance occurs in sampling
	Site index units
3	± 25
5	± 13
8	± 8

Obviously, an average of site index based on only a few trees may differ considerably from the corresponding true site index. When site measures of two areas are compared it is important to recognize that both are subject to sampling error. If the averages are based on too few measurements, the differences in site may be more apparent than real.

Information on "Growth of Ponderosa Pine" available from previous work was published in the Journal of Forestry during the year.

A paper by Johnson of the Experiment Station and Hixon of the Regional Office on the efficiency of various plot sizes and shapes for cruising Douglas-fir old growth was submitted to the Journal of Forestry.

Work on the preparation of regional volume tables for lodgepole pine was started with the cooperation of timber management men on the national forests, the Colville Indian Reservation, and the Oregon State Forester's staff.

Increase in the application of thinnings in young Douglas-fir emphasizes the need for sound information on the levels of growing stock required to obtain optimum increment. Years of intensive management experience will be required to develop precise answers to this problem. But, in the meanwhile, foresters need the best data that can be provided now to guide their everyday work. Such a new interim stocking guide was developed during the year. Based on growth records of Douglas-fir in the Pacific Northwest and in Denmark, the proposed guide shows desirable density in terms of numbers of trees, basal area, and spacing for stands of different average diameter and average height. The new density guide is given in part in the following table:

Desirable number of trees per acre for Douglas-fir stands after thinning, by average diameter and height

Av. d.b.h.	Average stand height in feet										
	30	40	50	60	70	80	90	100	110	120	130
Inches:	Number of trees										
4	935	1425	1912								
5	486	773	1061								
6		457	643	828							
7		294	423	553	682						
8			292	386	480	575					
9			207	278	350	422					
10				206	261	317	372				
11				155	199	243	288	332			
12				119	155	191	227	262	298		
13					122	152	181	211	241		
14					98	124	149	174	199	224	
15						100	121	142	163	184	205

The relationship between total growth and growing stock, as measured by this standard, was found to follow similar trends in Denmark and in the Northwest. This indicates that the very high yields the Danes have achieved in intensively managed Douglas-fir can be duplicated in Oregon and Washington by the maintenance of similar growing stocks.

Maximum net increment in the Northwest was obtained when growing stock was maintained approximately at the level shown in the above table. Results of the study are being summarized for publication in the Journal of Forestry.

There was increasing cooperation during the year with the Division of Timber Management and the national forests in the preparation of management plans and cutting budgets.

Fire Studies

Fire danger rating. Fire control men still do not have a satisfactory method for measuring and rating the weather elements of forest fire danger. No system tried has answered all of the needs for a simple, accurate, easily measured, readily understood rating that can be forecast a day in advance or reconstructed as a matter of history to show the ease with which a fire would start and the probable rate of spread in any fuel from light grass and weeds in the open to duff under the green timber.

We continue testing and trying to improve the methods of rating now in use. During the past year, as described below, this work was concentrated on three parts of the problem: (1) daily advance estimates of local fuel moisture and wind velocity from Weather Bureau forecasts and local records, (2) localizing Weather Bureau wind forecasts, and (3) rating the severity of the fire season as a whole.

In 1949 a method for making daily advance estimates of local fuel moisture and wind velocity from Weather Bureau forecasts and local observations was devised and sent to the national forests in this region for comments. During the past year the methods and description were improved, and six ranger districts were selected to give it a thorough test by daily use. The object of the test was to learn: whether the prerequisite analysis of past local records was too intricate for normal field use; whether the process description would be correctly interpreted and followed; whether after actual use the field men would consider the estimating system a worth-while aid; whether under field conditions the system gives more accurate estimates of future fuel moisture and wind than the informal estimates commonly made according to personal experience; and what changes in the system are needed. The trial experience was discussed with the field users at the end of the season, and numerous suggestions for improvement were received. These men, in general, found the system a valuable aid. The greatest cause of inaccuracies appears to be the wide local variations from forecast wind velocities. Before the 1951 fire season we will make a day-by-day comparison of the field advance estimates and actual fuel moisture and wind measurements on each of the six districts.

In cooperation with the Weather Bureau, the accuracy achieved in using wind forecasts in fire danger rating was tested. In the usual fire

weather forecast, winds are predicted for well-exposed parts of a broad area such as an entire national forest or county. Over rough topography the wind differs greatly with location, but nevertheless the forest fire control man must plan his control for each location according to an advance estimate of the wind. Some have suggested that a wind survey be made from existing or new measurements for each ranger district so that Weather Bureau forecasts for one key station can be converted to estimates for other locations. Before doing this we should determine if the wind can be predicted 12 to 24 hours in advance for the key station with the accuracy needed for planning fire control activities.

Assisted by the Weather Bureau we selected 13 well-exposed mountain peaks in various parts of Oregon and Washington for which wind gage records covering several years were available. Several were visited to check the anemometer location and wind eddies around the peak. The stations were asked to determine each day the average wind direction and speed during the half-hour before 4:30 p.m. The measurements were immediately sent to the Weather Bureau to assist in forecasting the next day's 4:00 to 4:30 p.m. average wind at each station. Forecast and measured winds for each day will be compared to learn if wind at well-exposed peak stations, more free from topographic effects than most locations in mountainous topography, can be satisfactorily forecast. Preliminary study of results from a few of the stations indicates wind speed forecasts for mountain areas are subject to considerable error even when made with special attention and for individual stations. Additional meteorological studies must be made to supply fire control men with accurate predictions of local wind.

Since weather is a principal year-to-year fluctuating factor of forest fire control, one frequently wishes to compare weather of the current season with the previous season or some outstanding or reference year. If losses are high, the administrator wants to know the reason and usually looks for a weather comparison early in his investigation. If losses are low, he wants to know if better prevention, better suppression, or better weather is responsible.

For such comparisons we have compiled each fall an index of average daily fuel moisture in the vicinity of the national forests for the period July 16-August 31 based on the fuel moisture indicator sticks. The mid-season period was chosen because continuous records are kept at a well-distributed network of stations in the national forests only when the stations are manned. In the frequent years when the weather is relatively safe before or after this period, no observers are on duty and no records are available for comparisons. Several recent seasons have had early spring or late fall dry periods in which more fire damage occurred than in mid-season. Consequently, the early and late season conditions merit greater attention, and the July 16-August 31 index is clearly inadequate.

In the fall of 1950 we tried new types of seasonal indices with the following qualifications in mind: (1) The basic data should be available for early and late season regardless of the degree of fire danger. (2) There should be records for the same station back to 1939 with the likelihood that records will continue in the future. (3) The records should be easily available so that indices can be computed and circulated as the interest demands during the season. (4) The weather factor measured should be one that is principally correlated with conditions affecting large areas.

One index tried was average number of days since the last rain of 1/4-inch or more. This index was computed for each of the periods April 1-June 30, July 1-September 15, September 16-October 31, and for the entire season April 1-October 31. The average is computed as follows: Assume that a day with 1/4-inch of rain is followed by a dry interval of 3 days. The first dry day contributes 1, the second 2, and the third contributes 3 to the grand total number of days since rain during the summer. The grand total is divided by the total number of days, including those with rain, in the summer period to get the average time since a wetting rain. Taking the simplest case for example, if a significant rain occurred June 30 but not again until September 16, the average number of days since a rain for the 76-day mid-season period July 1-September 15 would be 38.5. If there had been no rain in the last part of the preceding period, those dry days would be included in the average. This index expresses very well the beneficial effect of frequent, well-distributed rains and the hazard of deep drying in soil, duff, and logs caused by continuous dry weather. It does not, however, indicate the critical danger of extremely dry fuels combined with high wind speeds that may develop during any dry period.

Some results of comparing the average number of days since a rain of 1/4-inch or more for the years 1939-1950 are: The 1950 season April 1-October 31 as a whole was about average except in western Washington where the average number of days since rain was less than usual. Compared with 1949, the 1950 season as a whole had fewer days since a wetting rain. For each section of the region the year with the greatest average number of days since a significant rain was as follows: western Washington - 1944, eastern Washington - 1939, western Oregon - 1940, eastern Oregon - 1949. The 12 annual indices for each section of the region show a low correlation with acreage burned.

A second rainfall index tried was the total number of days without rain in each of the periods listed above. Unlike the average number of days since a rain, this index gives very little indication of prolonged dry periods. Furthermore, it showed much smaller differences between years. It is, however, a necessary complement to the preceding index. Two years or seasons may have the same average number of days since a wetting rain, but a significantly different total number of rainless days when fires presumably might spread. For example, in western

Washington during the July 1-September 15 period the average number of days since a wetting rain was about 11 in both 1950 and 1948, but the total number of rainless days was 65 in 1950 and only 49 in 1948.

A third index being tried but so far only in the exploratory stage is a daily afternoon relative humidity and wind speed combination expressed in terms of probable relative rates of spread of going fires in flash fuels. The principal day-to-day fluctuations in rate of fire spread are fuel moisture content and wind speed. Relative humidity can be used to estimate moisture content of the fine flash fuels. Relative humidity and wind speed measurements throughout the year are available from Weather Bureau and airport stations 50 to 100 miles apart in the settled parts of the region. The open and level exposure of most of these stations is desirable for an index of broad area wind movement.

Slash burning. The most critical unsolved broad problem in fire control west of the Cascades is logging slash. It has long been recognized as the most dangerous type of fuel and the current cutting rate causes several hundred thousand acres of fresh slash per year. Slash has usually been burned to reduce the hazard, but in recent years with more attention given to the effect of fire on site, restocking, and watersheds, and to the escape of slash fires, some foresters have questioned the net value of slash burning.

We are trying to measure net value of slash burning by a large number of paired plots in which both plots of each pair have nearly identical slash, slope, aspect, soil, brush and weed cover, and distance from seed supply. One of the plots in each pair is burned and the other left unburned. To allow more perfect pairing the plots are usually only about 1/4-acre in size. Severity of burning on the burned plot and kind and quantity of slash and cover on the unburned are recorded soon after burning. Amount and kind of herbaceous, brush, and forest seedling growth are then measured annually, and the fire hazard is rated by the fuel type classification system. In 1950, 23 pairs were examined for the first time, and 29 older pairs were re-examined. In the fall, locations for 47 new pairs were selected for burning.

Although the number of plots and years of observation are too few for conclusions, the following trends in coniferous restocking and plant cover are appearing:

In the third growing season after logging and burning there was better stocking on the unburned than on the burned plots, but only 3 out of the 8 unburned plots available for comparison were well stocked. All of these comparisons were in Oregon in the central Cascades.

There is more brush on the unburned than on the burned plots, but in the fourth season after cutting in the central Cascades of Oregon it covers from less than one-fifth to two-fifths of the area. Up to the

fourth growing season after burning in that locality, burning reduced the proportion of rhododendron and increased the proportion of ceanothus and blackcap.

In the central Cascades of Oregon the total density of herbaceous cover was slightly greater on the burned than on the unburned plots the second season, about equal the third season, and slightly less the fourth season. On both burned and unburned plots the herbaceous cover density was greater than the brush density during the third and fourth seasons.

Prescribed burning in ponderosa pine. A 21-acre plot in dense understory ponderosa pine that was burned with a prescribed backfire by Colville Indian Reservation foresters in 1942 to test the use of fire as a thinning practice was re-examined in cooperation with the Reservation foresters last spring. Several hundred saplings that were tagged and measured as potential dominants on the burned and unburned area soon after the fire were remeasured to compare height and diameter growth. These measurements are scheduled for analysis this winter.

The job ahead - planned for 1951. Complete the study of different types of fire season severity indices readily derived from the records of year-long weather stations. The most useful of these indices then should be periodically computed and circulated to the field for the elapsed part of the 1951 season as it progresses. Field tests on six ranger districts will be analyzed to determine the practicable value and weaknesses of the procedure for estimating local fuel moisture and wind. Results of last summer's cooperative Weather Bureau-Forest Service field test of wind forecasts for specific, well-exposed points will be analyzed and used in planning further wind studies needed to improve predictions of fire danger. Since the most critical fire weather west of the Cascades results from east winds, the study of the past frequency of these winds in different months will be finished and published for use in estimating the danger in slash and debris burning in different months. Measurements of fire weather factors during the past six years at a mountain valley and overlooking peak station will be analyzed and published. Measurements on hand showing the relation of hourly moisture content of several kinds of fuel and the associated relative humidity, temperature, and wind velocity will be charted and published.

The 52 paired plots of burned and unburned slash will be examined, and those new ones successfully burned last fall will be established. Trends of cover and regeneration will be reported. Fire behavior and the contributing weather, fuel, and slope factors on wild fires and broadcast slash burning fires will be measured at every practicable opportunity. Such data from previous years will be analyzed and published. Analysis of the routine individual fire reports for all national forest fires in the region will be completed to determine the relation between past fire danger ratings and fire size.

Important studies that need attention. Field study should be made to determine if there is sufficient correlation between the summer winds in various parts of a mountainous area, such as 100,000 acres, to allow practicable estimates of wind throughout the area from measurements at one or two exposed points. Effects of managed fires under prescribed conditions in dense sapling stands in the ponderosa pine region should be measured. Measurements of wild fire and slash fire behavior and the contributing factors should be accumulated more rapidly than is now possible. Test-fires with sufficient men to manage and study them should be used to learn more rapidly the effects of fundamental fire behavior factors upon fires burning in the particular fuels of this region. Useful information given on the individual reports describing the circumstances of each of several thousand fires should be summarized more completely and distributed for the use of fire control men. Fire mop-up is known to account for a large part of fire suppression cost and improvements, yet efficiency and time studies of mop-up jobs have not been made. The possibilities of cost savings make such a study important. The known relative advantage of "wet" water over plain water for suppressing fire should be tested for the various slash fuels of the region.

FLOOD CONTROL SURVEYS

After its first full year of operation as a unit, the Division of Flood Control Surveys is well under way in its contribution to the Columbia River Basin agricultural program. In the flood-control part of this job, the principal objects are: (1) to determine where and how often damages due to floods, erosion, and sedimentation occur; (2) to locate flood and sediment source areas and to outline flood and erosion causes; (3) to develop a program of land management and improvement that will reduce stream flow peaks, flood severity, and sediment production; and (4) to compare the costs of possible programs of management and improvement with the benefits deriving from reductions in floods and sedimentation.

As plans were developed for these investigations, rather clear-cut assignments were set up for Flood Control Survey personnel. They carry the entire responsibility for working out damage appraisals, hydrologic analyses, studies of present and past conditions, and preparation of programs on sample areas throughout the portion of the Columbia Basin which is assigned to each Station. Along with these jobs, the Flood Control Survey groups are working with the U. S. D. A. Field Committee for the comprehensive agricultural program in the preparation of information on present physical, biological, and economic conditions in the basin; will take part with the Field Committee in analysis of various problems of land management in the basin; and are working with the administrative branch of the Forest Service and other agencies in preparing information on the comprehensive program itself.

The integration of flood-control survey work with that of the comprehensive program began early in 1950. As the first step, the technical subcommittees of the Flood Control Survey offices of the Columbia River Basin prepared a detailed outline for a working plan for the basin flood-control survey. As soon as an Interim Task Force was established to carry on comprehensive program activities pending the establishment of a Field Committee, the flood-control working plan outline was incorporated into a broader outline for the comprehensive program. Including details from a statement of principles and policies for the Columbia Basin program which had been issued by the Secretary of Agriculture's office, this outline was expanded into a relatively detailed working plan.

With the final establishment of the Field Committee and assignment of most of its working members after the beginning of the current fiscal year, activities on the comprehensive program began to take more definite form. Throughout the course of this development, the Pacific Northwest Station has represented the Flood Control Survey groups in all Field Committee activities.

Progress on Field Work

Flood-control survey work began in earnest with reconnaissance trips of the Washington and coastal Oregon areas by various members of the survey. The Olympic peninsula (except for watersheds tributary to the Chehalis River) has been largely eliminated from flood-control consideration--though floods are frequent there--because of the limited development and low damages relative to the high costs of control measures, which would have to be primarily structural. For other areas, selection of sample watersheds for hydrologic analysis followed the reconnaissance. Because of their similarity in climate, the Oregon Coast, southwest Washington, and Puget Sound areas were considered as a unit for this purpose, and 15 watersheds scattered over these three areas were chosen for detailed study in the analysis. An extensive soil sampling gave information on soil textures and depths, and on geology. Further data on geology were taken from State geological maps. Forest Survey maps and tables were used to delineate forest areas and cover types, with aerial photographs, fire records, logging records, and field inspection used as needed to bring the cover information up to date.

Climatic data from Weather Bureau records and stream-flow data from Geological Survey records were then compiled for the sample watersheds. Maps of cover and land use showing forest types by age-classes were drawn, and areas of each class tabulated therefrom. Similar maps and tabulations were made for geology and soils. Data on agricultural lands and types of culture were obtained from the Soil Conservation Service. A multiple regression analysis involving all these factors was then set up, to determine the effect of each on stream flow. Computations involved in this regression are still going on; first results are expected early in 1951.

Descriptive reports on physiography, climate, cover, land use, and development of the coastal Oregon and western Washington watersheds are now being prepared. Though part of the final survey write-up, these reports are being kept current as we come to each new work area.

Related Studies

Among the areas selected for hydrologic analysis in the flood-control survey is the Green River watershed which supplies water to the city of Tacoma. Aside from our own hydrologic studies, the U. S. Geological Survey is also using this area for investigations of the effects of forest vegetation and its removal on watershed hydrology. In the way of cooperation with the city of Tacoma and the Geological Survey on this investigation, the Pacific Northwest Station has arranged for topographic mapping of the area, and copies of the detailed cover and geology maps made for the hydrologic analysis will later on be given to the Geological Survey.

A work plan for watershed management studies on the Blue River Experimental Forest is in the final stages of preparation. Specifications in timber sale contracts for the experimental forest now include detailed provisions for safeguarding streams and for controlling road drainage and erosion. Two inspection trips were made this past year, to obtain firsthand information for the work plan, and to locate sites for stream gages in the small watersheds selected for intensive study.

Within the Starkey Experimental Range above La Grande, Oreg., a series of experimental pastures has been established by the Range Research Division, within each of which a small watershed has been included. These watersheds appear to be very suitable for special study of the effects of several grazing treatments on water yields, peak discharges, and sediment production in the ponderosa pine-grassland type of the Blue Mountains.

In the eastern Washington Cascades, a group of seven small watersheds tributary to the Entiat River on the Wenatchee National Forest was selected for future watershed management studies in the ponderosa pine and mixed-conifer timber types. This proposed study area contributes water to the irrigated fruit orchards of the Wenatchee area, and is visited by numerous tourists and other recreationists each year. The watersheds range from 2 to 5 square miles in area; all have permanent flow and are accessible the year around. There has been some grazing in three of the watersheds, but no logging. Geologic formations, topography, aspect, cover, and soil types are similar on all seven. Studies would include the effects of fire, grazing, logging, and road building on quantity and quality of the water supply.

Initial observations and conclusions from the study of soil freezing have been summarized in a report. Since soil freezing was found to be

insignificant in heavily timbered areas, the study is being continued this season only on the range and related forest lands of eastern Oregon. The final report on this study should be made by the summer of 1951.

A study directed toward finding what relationship might exist between time (age of stand) since logging or burning and soil characteristics was made on two coastal soil types in the Douglas-fir forest. Percolation rate was found to be correlated with volume-weight, but there were no significant correlations of the measured soil characteristics with age of stand. The data--though not conclusive enough to establish final relationships--suggest that percolation rate increased rapidly from zero to 20 years, decreased from 20 to 30, then climbed slowly through age 60. Further study is needed on the younger age-classes and on other soils.

Sedimentation studies were begun in the fall, with biweekly sampling of suspended loads in several west-side drainages in Oregon and Washington. It is planned to tie this sampling to the hydrologic analysis, so that flood and erosion control program effects on suspended loads may be evaluated. Some of the samples taken were collected during the late October floods in southern Oregon. The highest value found--3.82 percent sediment--came from the South Fork of the Coquille River at about the flood peak.

To make the analyses of the various soil and sediment samples, a soils laboratory was set up in the regional shop. The laboratory is equipped for current analyses of soil volume-weights, percolation rates, retention and detention storage, soil particle size distribution, and soil pH.

The Flood Control Survey Division also took part in several joint studies with other divisions. With Forest Management Research, a study was begun on the effects of various high temperatures (such as accompany slash fires) on soil pH and physical structure. Another study, in cooperation with Forest Management Research and the Regional Office Divisions of Timber Management and Engineering, is aimed at developing detailed specifications in timber sale contracts for road layout, road construction, timber sale layout, and logging operations, to reduce erosion, protect stream-flow quality, and decrease road maintenance costs.

A special report on the October floods in southwestern Oregon and northwestern California was prepared and is now being distributed. The floods followed the heavy rains of October 27 to 30 on watersheds already saturated by previous rains, and did considerable damage in the South Umpqua, Coquille, Illinois, and Smith River drainages. On one or two streams the flood peaks reached were the highest of record. The storm that broughton the flood was accompanied by strong winds that blew down considerable volumes of timber and disrupted communication lines over a much wider area than was affected by the floods.

Cooperation

For the Green River and Clackamas River watersheds (used as sources of domestic water supply) recommendations regarding location of logging areas and access roads, road stabilization and drainage control, and specifications for logging operations near stream channels, were made in answer to requests from the city of Tacoma and the Bureau of Land Management. An inspection trip on the Olympic National Forest was made to see what help might be given toward solving some difficult road construction problems in areas of steep topography, heavy soils, and high rainfall.

Plans for Next Year

The Pacific Northwest Station will continue to coordinate flood-control survey activities of all the survey groups involved in the Columbia River Basin. Our personnel will also help integrate the flood-control survey work into that of the Field Committee on the comprehensive agricultural program, and will contribute directly in preparing program material. This will include compiling and summarizing data obtained from various parts of the Columbia River Basin on physical, biological, and economic resources and conditions; on flood control and other problems; and on current and contemplated programs.

Flood-control survey field work will include finishing the hydrologic analysis for the west-side Washington and Oregon areas and beginning the analysis for the eastern Washington and northeastern Oregon watersheds; collecting land-use and condition data for forest and public range lands in the Soil Conservation Service areas of responsibility in Oregon; obtaining program data on the Project Work Inventory revision for the national forests; and collecting general land-use, physiographic, cover, flood damage, and development data for our east-side areas of responsibility. During the next season, the engineering section will begin locating sites for channel structures, and with the economics section will evaluate these structural program possibilities.

In related studies, next year's plans call for installation of stream gages and a recording precipitation gage in the three small watersheds at Blue River Experimental Forest; drawing up working plans for watershed management studies on the Entiat watersheds and at the Starkey Experimental Range, and if possible installing stream gages and other equipment; finishing and reporting on the soil freezing study; continuation of suspended load sediment sampling in west-side streams, with expansion to east-side streams if the sediment load measurements can be tied in to the hydrologic analysis; and continuation of the studies on relationships between soil condition, age of cover, and land treatment.

Cooperation with the city of Tacoma and the U. S. Geological Survey on the Green River watershed study will probably be restricted to furnishing topographic maps and to inspecting logging operation and access road layouts. Division personnel will also continue to act as consultants on watershed problems when asked for help by other divisions or agencies. It is hoped that before the field season begins a list of detailed specifications for soil stabilization and drainage and erosion control on access roads and logging areas can be furnished to field administrative officers working on timber sales. This project will be carried out in cooperation with the Division of Forest Management Research and the Regional Office Divisions of Engineering, Timber Management, and Lands.

FOREST INSECT INVESTIGATIONS

(Bureau of Entomology and Plant Quarantine
in cooperation with Forest Service)

Spruce Budworm Control

Aerial spraying with DDT for control of the extensive epidemic of the spruce budworm in Oregon and Washington was continued with the treatment of 934,000 acres in 1950. The project was jointly administered by the Forest Service and the Oregon State Board of Forestry. The Bureau of Entomology and Plant Quarantine provided technical supervision.

Despite a spread of the outbreak on untreated areas, the over-all infestation was reduced by control from 2,276,000 acres in 1949 to 2,036,000 acres in 1950. Most important, the area of heavy infestation was reduced from 887,000 acres in 1949 to 185,000 acres in 1950, thus greatly lessening the threat of wide-scale forest destruction by the budworm. The average cost for treating was $1.06 per acre in 1950 as compared with $1.15 per acre in 1949. Plans were made to spray approximately 1,000,000 acres in 1951.

An experiment to develop control measures against the migrating larvae of the budworm in mid-summer and thereby extend the time available for control proved negative. However, an experiment with reduced amounts of DDT showed that three-fourths of a pound per acre gave essentially the same degree of control as the 1 pound per acre application previously used. The three-fourths-pound rate will be used on the 1951 project and will be helpful in offsetting an acute shortage of DDT and the rising costs of materials and services.

An intensive study of the biology of the budworm in Oregon and Washington was begun in 1950. The emphasis was on the natural control factors and their relative effectiveness. Some evidence of a natural break in infestation was noted on the Wallowa National Forest, but elsewhere the budworm increased on the unsprayed areas.

Aerial Survey Techniques

Experiments were undertaken to develop and improve aerial methods of detecting and evaluating tree mortality both in ponderosa pine and in Douglas-fir stands. The emphasis was on aerial photography.

Earlier studies had shown that insect-killed ponderosa pines of some types could be recognized on large-scale aerial photographs. In 1950 detailed studies were made to determine the best film-filter-scale combination for determining mortality in ponderosa pine stands. Eleven film-filter combinations were tested at scales of 1/2500, 1/5000, and 1/7500. The results are still being avaluated by a series of experienced photo interpreters.

Forest Insect Conditions

The annual survey of insect-caused losses in the forests of Oregon and Washington was expanded under the provisions of the Forest Pest Act. The State of Oregon carried a large share of the aerial detection phase of the program in Oregon. Private foresters, both in Oregon and in Washington, also contributed much, especially in determining the status of the spruce budworm.

The spruce budworm reported as epidemic on 2,036,000 acres remained the most serious insect threat to the forests of the Northwest. Some 30,000 lodgepole pines currently infested with the mountain pine beetle were recorded on the Wanoga Butte area of the Deschutes National Forest. Fir engraver beetles continued to deplete the silver fir stands of northern Washington. On the Olympic Peninsula an outbreak of the hemlock looper subsided without causing serious loss. Infestation of ponderosa pine by the western pine beetle was very low throughout the region.

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PERSONNEL

ADMINISTRATION

J. Alfred Hall	Director
Samuel E. Kistler	Administrative Officer
Daniel W. Richmond	Chief Clerk
Frances Elliott	Secretary
Erna J. Jeppesen	Librarian
Edgel C. Skinner	Statistical Clerk
Leah Wheeler	Clerk-Typist
Ruth B. Ufen	Statistical Clerk
George I. Hall	Misc. Dup. Mach. Operator

FOREST ECONOMICS

Robert W. Cowlin	Forest Economist
Floyd A. Johnson	Forester
A. Kathryn Flaherty	Draftsman
Emma G. Johnson	Clerk-Stenographer

Forest Survey Inventory

Richard C. Wilson	Forest Economist
Carl E. Mayer	Forester
Walter R. Johnson	Forester
Robert B. Pope	Forester
Charles E. Tyler	Forester
John A. Sandor	Forestry Aid
Margaret J. O'Kane	Statistical Clerk

Forest Resource Analysis

Floyd L. Moravets	Forest Economist

FOREST UTILIZATION SERVICE

Edward G. Locke	Technologist
Archibald C. Knauss	Technologist
Vivian B. Heigh	Clerk-Stenographer

RANGE INVESTIGATIONS

Joseph F. Pechanec	Range Conservationist
Robert S. Rummell	Range Conservationist
Christina McPhail	Clerk-Stenographer

FLOOD CONTROL SURVEYS

Harold G. Wilm	Forester
LaVone F. Cable	Clerk-Stenographer
Mary Lou Boyko	Clerk-Typist

Hydrology

William K. Nelson	Hydraulic Engineer
Robert L. Hobba	Forester
Melvin P. Twerdal	Forester

Land Use

William E. Bullard, Jr.	Forester
Charles E. Hale	Forester
Richard S. Sartz	Forester
Manes Barton	Forestry Aid

FOREST MANAGEMENT RESEARCH

Philip A. Briegleb	Research Forester
Robert F. Tarrant	Soil Scientist
Willard H. Carmean	Research Forester
Ethel T. Arthur	Clerk-Stenographer
Elvera E. Hamm	Clerk-Stenographer
Margaret E. Michels	Clerk-Stenographer

Silviculture

Leo A. Isaac	Forester

Applied Forest Management

Elmer E. Matson	Forester

Forest Protection

William G. Morris	Forester
Owen P. Cramer	Meteorologist

Experimental Forests

Blue River Experimental Forest - McKenzie Bridge, Oreg.

Roy R. Silen	Forester

Cascade Head Experimental Forest - Otis. Oreg.

Robert H. Ruth	Forester

Wind River Experimental Forest - Carson, Wash.

Robert W. Steele	Forester
William I. Stein	Forester

RESEARCH CENTERS

Blue Mountain Research Center - La Grande, Oreg.

Clark E. Holscher	Forester
George A. Garrison	Range Conservationist
Ellerslie W. Stevenson	Range Conservationist
Norma I. Nemeth	Clerk-Stenographer

John Day Experimental Forest - Unity, Oreg.

Walter G. Dahms	Forester

Starkey Experimental Forest and Range - La Grande, Oreg.

Robert W. Harris	Range Conservationist

Willamette Research Center - Corvallis, Oreg.

Robert Aufderheide	Forester
Harold A. Rapraeger	Forester
Margaret E. Michels	Clerk-Stenographer

Puget Sound Research Center - Olympia, Wash.

Norman P. Worthington	Forester
George R. Staebler	Forester
Elmer W. Shaw	Forester
Ruth L. Kellum	Clerk-Stenographer

Siskiyou-Cascade Research Center - Roseburg, Oreg.

G. Lloyd Hayes	Forester
Edward S. Kotok	Forester
Mary H. Winn	Clerk-Stenographer

Port Orford Cedar Experimental Forest - Powers, Oreg.

George A. James	Forester

COOPERATING AGENCY

FOREST INSECT INVESTIGATIONS

Robert L. Furniss	Entomologist
John M. Whiteside	Entomologist
William K. Coulter	Entomologist
Alexander T. Davison	Entomologist
John F. Wear	Pilot
Walter J. Buckhorn	Scientific Aid
Kenneth H. Wright	Scientific Aid
Olga M. Wulff	Clerk-Stenographer
Anne M. Hobba	Clerk-Stenographer